SPE JOURNAL

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14-A

INJECTION MOLDING WHICH PATH

PLUNGER OR MOVABLE SCREW

page 539

Among the important factors in Shell Chemical's decision to make polystyrene were its extensive background in polymers and its raw material position. Two other Shell thermoplastics followed quickly—polypropylene and polyethylene.

BULLETIN:

On May 3, 1960, a remarkable thermoplastics decision was made by Shell Chemical

Read about this Shell decision. And how you can start benefiting today from a major new source of polystyrene, polypropylene and polyethylene that resulted from it.

ON MAY 3, 1960, Shell Chemical, a company long basic in styrene monomer and SBR rubber, decided to combine the two in full commercial production of Shell high impact polystyrene. Why was this remarkable?

A revealing fact on polystyrene

The condition of the polystyrene market was not attractive. There was oversupply from some of America's finest companies. The field was mature and Shell was starting late.

One revealing fact offset this situation. *Shell, with its excellent background in polymer chemistry—as exemplified by Shell Isoprene Rubber, the industry's first commercially produced synthetic/natural rubber—could make positive contributions to the thermoplastics field in the form of new products.* But Shell would be severely handicapped without a thorough understanding of how the thermoplastics market works and what it wants.

Result? Shell's decision to go full speed ahead with high quality general purpose, medium and high impact Shell polystyrenes, plus a rapidly expanding technical sales force.

80 million pounds of polypropylene

Two other thermoplastic developments followed quickly.

One, Shell's announcement in October, 1960, for an 80 million pounds a year polypropylene plant with customer service and research facilities to be built near Woodbury, N. J. Two, an arrangement by which Shell will resell limited quantities of polypropylene until this plant comes on stream.

Custom-made polyethylene

And this, in turn, led to a third important thermoplastic.

In order to round out a complete line of thermoplastics, Shell Chemical, in January, 1961, made arrangements to supply the industry with the highest quality custom-made polyethylenes.

How to start benefiting

Thus, within 8 months, Shell became an important factor in three plastics: Shell polystyrene, Shell polypropylene and Shell polyethylene.

The next 8 months should be even more important. Shell will be going full speed ahead searching for new polymers you want.

Now is the time to let Shell's technical representative know your needs. Tell him about them on his next visit or write Shell Chemical directly at:

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A Bulletin from

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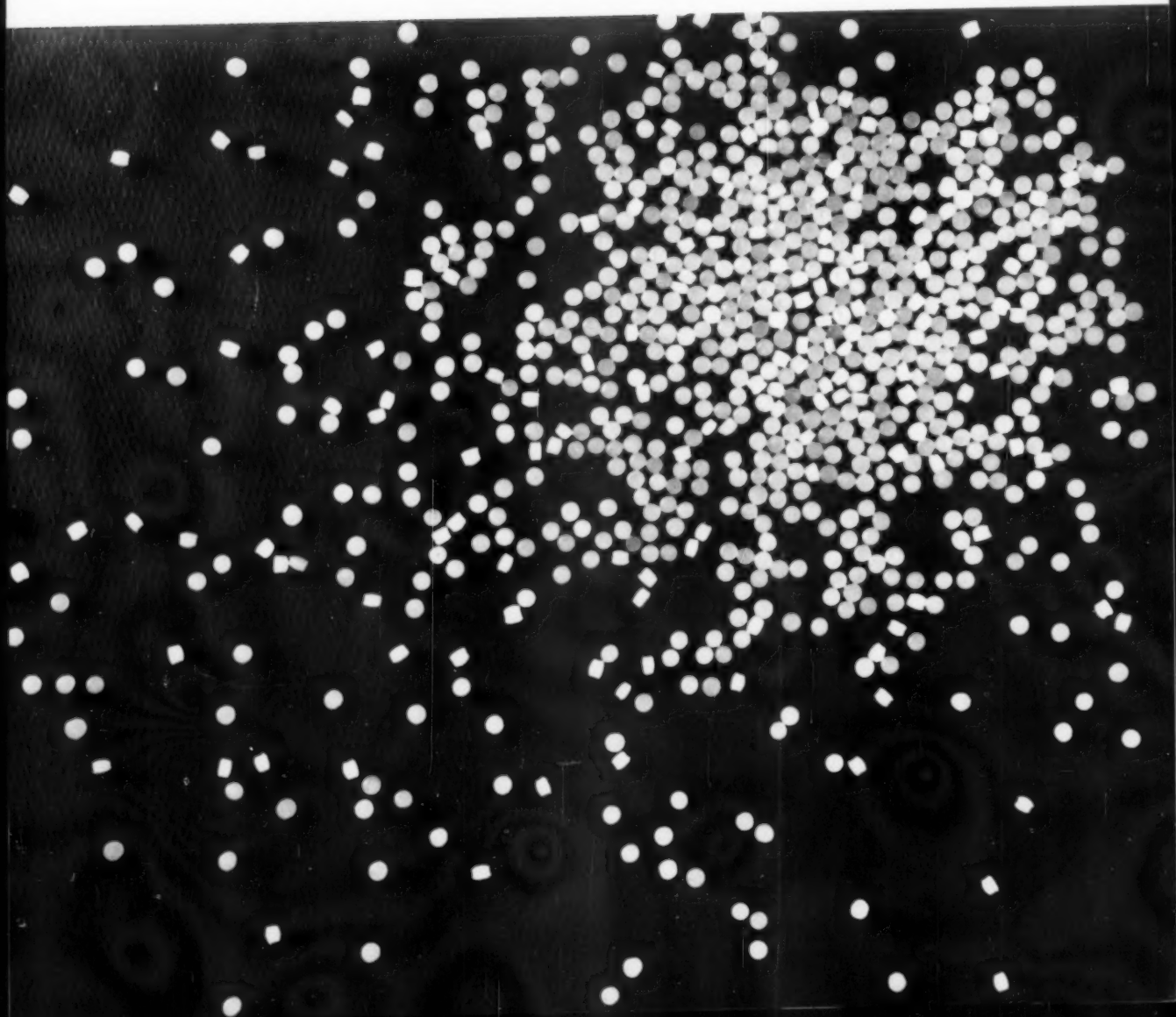
A NEW DURABLE HIGH DENSITY POLYETHYLENE EASILY SHAPED INTO PROFITABLE PRODUCTS



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that combines durability with processibility

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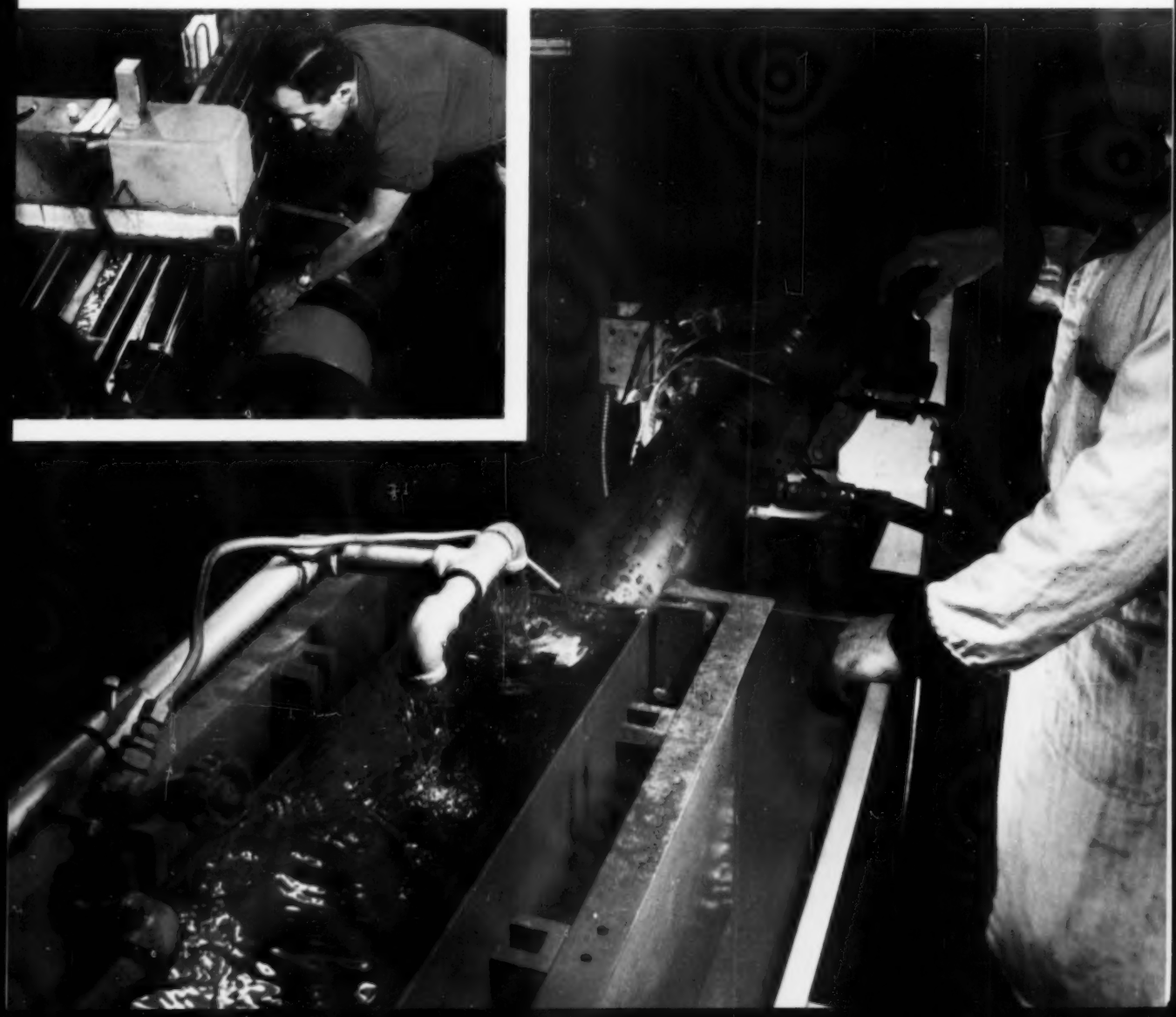

AMERIPOL POLYETHYLENE HAS SUPERIOR PROPERTIES THAT WILL PAY OFF IN YOUR PRODUCTS

	ASTM		AMERIPOL GRADE NO.		
Physical Property	**Units**	**Method**	**32**	**34**	**35**
Density	g/cc	D648-56	0.95	0.95	0.95
Molecular Weight	———		50,000	80,000	100,000
Melt Index (condition E)	g/10 min	D1238-57T	0.1-0.2	0.04-0.08	0.001
Flow Index (a) (condition F)	g/10 min	D1238-57T	24.0-28.0	8.5-9.3	4.0-5.6
Intrinsic Viscosity	———	D1601-58T	2.3-3.0	3.1-3.7	3.8-4.8
Vicat Softening Temperature	°C	D1525-58T	119	121	122
Ultimate Tensile Strength, 20 ipm	psi	D412-51T	2250	2450	2700
Tensile at Yield, 20 ipm	psi	D412-51T	3450	3450	3450
Elongation, 20 ipm	%	D412-51T	120	320	560
Impact Strength (b)					
⅛ x ½ bar	ft/lbs				
	in notch	D256-54T	19	31	36
¼ x ½ bar	"	D256-54T	8	17	24
½ x ½ bar	"	D256-54T	0.9	1.9	4.3
Stiffness in Flexure	psi	D747-50	115,000	115,000	120,000
Hardness	Shore D	D1706-59T	60	60	60
Environmental Property					
Environmental Stress Cracking (c)					
With Anti-oxidant	hrs.		65	445	>800
Without Anti-oxidant	hrs.	D1693-59T	40	230	500
Thermal Embrittlement (d)					
With Anti-oxidant	hrs.	(d)	185	>1000	>1000
Without Anti-oxidant	hrs.	(d)	70	95	700

(a) Cutoff on flow index test made at the end of 30 seconds.
(b) The impact strength test result is greatly influenced by sample size.
(c) ASTM Standard on Plastics. D1693-59T Method of Test for Environmental Stress Cracking of Type I Ethylene Plastics. This test, which has been adopted for Type I Ethylene Plastics is used herein for Type III in the absence of an official method.
(d) This test employs compression molded specimens, 5" x 0.25" x 0.05", three of which are wrapped and clamped around a ¼" mandrel. The apparatus is inserted in a nitrogen blanketed test tube which in turn is placed in an aluminum block @ 100°C. The value reported is the time until two of the three samples crack.

How to put this new polyethylene to work in your operation

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SPE JOURNAL
VOL. 17 • NO. 6
JUNE 1961

COVER: Screw plasticizing for injection molding developed in Europe is gaining momentum on this continent. The article beginning on page 539 takes a close look at this molding innovation.

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Special Feature

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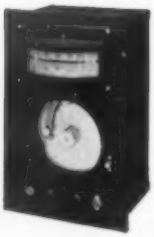

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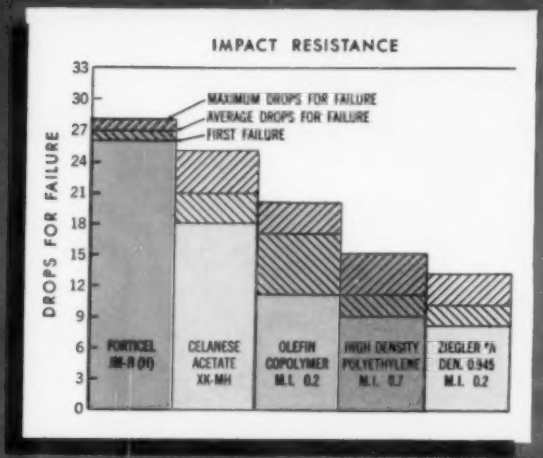

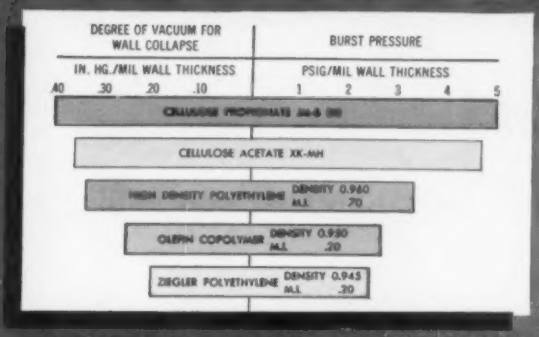

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The Injection Press Picture — A New Principle Enters

If you visited the SPI Plastics Exposition in New York earlier this month, you saw how the movable screw injection molding machines have burst into full bloom. What impact will this have on the American plastics industry? Will plunger molding be made obsolete overnight as it was in Europe?

The answers to these questions—and others—can be found in the article written by A. R. Morse, President of Injection Molders Supply Co., page 539, this issue. The article is entitled Movable Screw Plasticizing Boom? It examines the various marketing and economic factors as well as technical factors of screw injection molding.

Mr. Morse suggests that a wait-and-see attitude now exists among American molders. Our own experience suggests there is really cautious acceptance among many processors. It is true there are only a few machines in American plants right now. But as Mr. Morse points out, one of the reasons for this is the fact that there is a considerable waiting period for delivery, in some cases 90 to 120 days.

Where is the movable screw plasticizing boom leading? This is the picture that is emerging:

- Molders processing heat-sensitive materials, for example rigid PVC, will be the first to place orders.
- Better color dispersion is also reported to rate high among reasons why molders want to buy screw injection machines.
- The transition to screw injection from plunger molding will be slowed considerably by the high number of very good preplasticizing units in operation.
- The full impact of American competition will not be felt for at least two years. Several companies have prototypes built, but deliveries are non-existent.
- Newcomers on the American scene are likely to be those machinery manufacturers which are a division or subsidiary of an already well diversified machinery building company.

The race is on. The stakes are significant.

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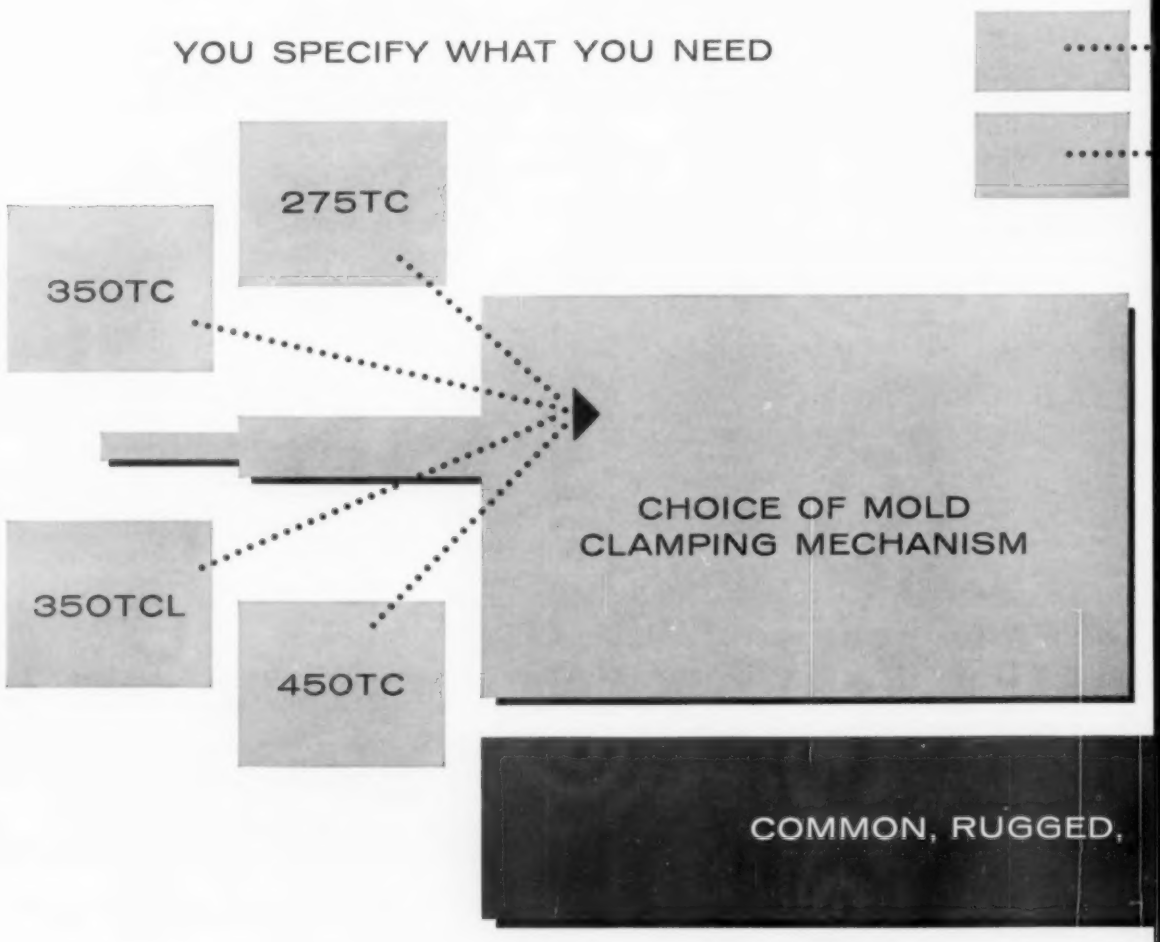

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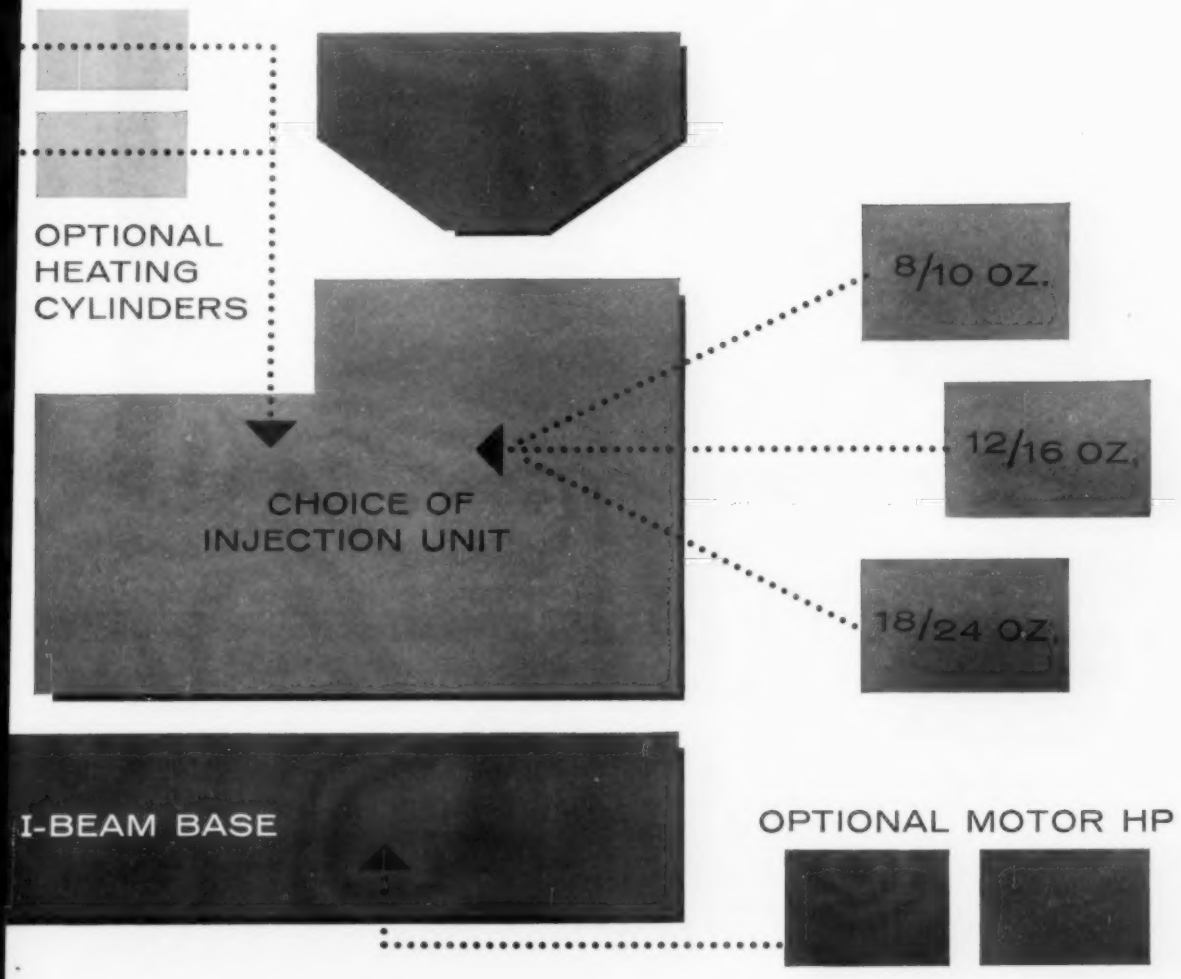

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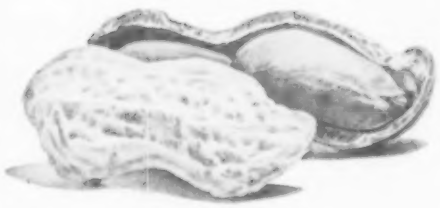

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Letters

Polyester Coatings

Dear Sir:

The writer would appreciate receiving literature relative to polyesters as corrosion resistant coatings.

Many thanks for your kindness.

H. Morgan
Laminating and Foliating Co., Inc.

Editor's Note

The above letter is in reference to the article titled Polyesters as Corrosion Resistant Coatings, by Lawrence Graubart, Reichhold Chemicals, Inc., published in the December 1960 SPE Journal.

Rotating Spreader

Dear Sir:

I read an article in the SPE Journal in which an injection molding machine may be upgraded by installing a rotating spreader.

I am interested in learning more about this process. Can you please send me any further information on this method. I would appreciate it very much.

John X. Winnicki
Continental Can Co., Inc.

Dear Sir:

In the March issue of the SPE Journal a statement appeared on page 219 to the effect that injection molding machines may be upgraded by installing a rotating spreader in the injection cylinder to give improved plasticizing, at a cost of approximately $4000.

J. Sutherland
Plastics and Metal Industries (Pty.) Ltd.
Johannesburg, S. Africa

Editor's Note

The Fellows Gear Shaper Co. in Springfield, Vt. is doing machine modification under license from the Du Pont Co., who developed the modification.

More on Status

Dear Sir:

Referring to Mr. Owen's letter published in the April issue, he objects to being labeled as a sales representative because it places him with the semi literate hucksters. We are consultants for those who decorate plastics. We manufacture two items and are sales representatives for four firms that serve those who decorate. We are proud of our representative status, and we are not ashamed of our technical or educational background. Also, we know of dozens of sales representatives whose technical and educational background equals or exceeds ours. Further, without the technical man in the field where is the line of communication between the shop floor and the ivory tower?

Your answer to his letter did, in no way, disagree with his expressed opinions. Your viewpoint would certainly be appreciated.

T. J. LaBounty
Midwest Technical Service

Editor's Reply

Your letter contains some thoughts we consider valid for all responsible technical salesmen.

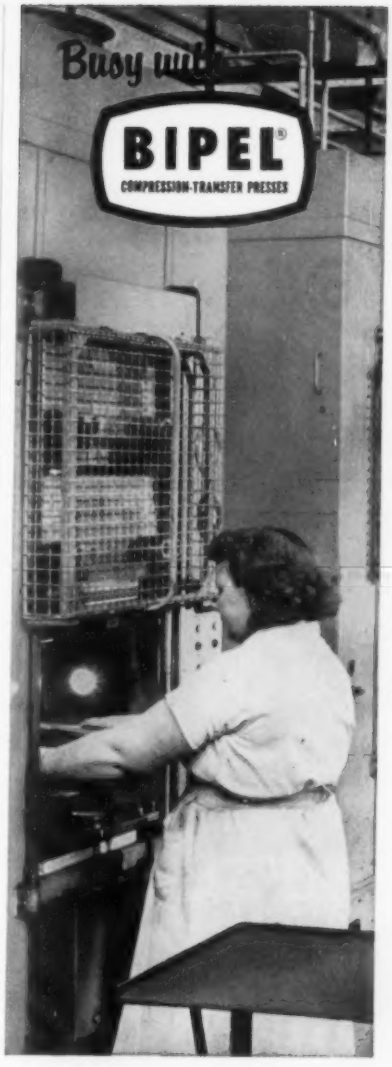
In reference to your last sentence, calling for editorial viewpoint on Mr. Owen's expressed opinion, we believe that the only portion of Mr. Owen's letter expressing a direct opinion is his statement "By listing me as a sales representative you place me in the same category with every semi-literate huckster of toys on the West Coast." We believe that Mr. Owen's choice of words may be somewhat ill-advised. Though he didn't say so in his letter, we also believe that it is implicit that anyone who identifies himself (or wishes to) as a sales representative also places himself in the same category with the thousands of chemists, chemical engineers, and other professional engineers who call themselves sales representatives.

In all of the above, we are assuming the word "technical" stands before sales representative, either in black and white or silently acknowledged. This, then, implies that the sales representative must be willing to assume the responsibility that goes along with being a professional.

Referring again to Mr. Owen's letter, it's one's own prerogative to choose a title, so long as it is reasonably descriptive of one's duties. But, we think the important thing is performance at a skill level high enough to go along with the title.

Have an Opinion?

Authors and editors like to hear from their readers. If you have any comments, opinions, or reflections on any of the articles in this issue, which you believe should be publicized, just drop a line to the Editor, SPE Journal, 65 Prospect St., Stamford, Conn.



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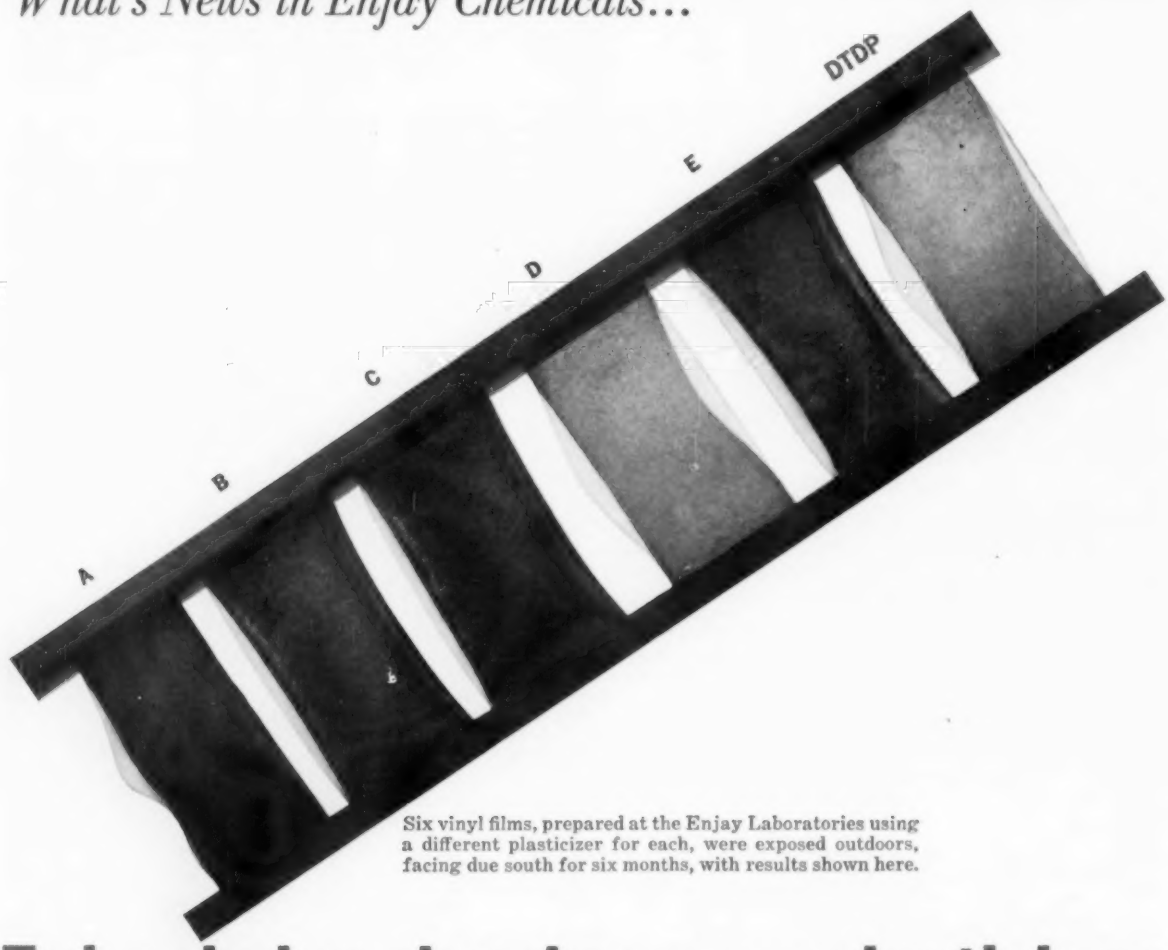
What's News in Enjay Chemicals...



Six vinyl films, prepared at the Enjay Laboratories using a different plasticizer for each, were exposed outdoors, facing due south for six months, with results shown here.

Enjay helps develop new plasticizer for vinyl film and sheeting...

As a service to plastic manufacturers, the Enjay Laboratories have just completed a broad evaluation and testing program on the use of ditridecyl phthalate—DTDP—as a plasticizer for vinyl film and sheeting.

In the outdoor laboratory test shown above, the DTDP plasticized film shown at right proved far superior in long term aging stability and had the least dirt pick-up and best clarity of the sample films tested. DTDP is readily synthesized from Enjay tridecyl alcohol and can offer manufacturers of items for outdoor applications a better quality, longer-lasting vinyl film with minimum soiling and excellent resistance to ultraviolet light. Other benefits of DTDP include: high resistance to extraction by soapy water • best color and lowest specific gravity of esters tested • low water absorption and extraction characteristics. For complete information on DTDP as a plasticizer for vinyl sheet and film ask for Enjay Technical Bulletin No. IC-23. Write to: Enjay, 15 W. 51st St., New York 19, N. Y.

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DOW PLASTICS TECHNICAL FILE

CHEMICAL RESISTANCE TESTS SCREEN PLASTICS FOR PRODUCT DESIGN APPLICATIONS

In selecting plastics for design use where the product will be subjected to a chemical environment, chemical tests are essential for primary screening purposes. The chemical resistance of a plastic is a physio-chemical effect, and is dependent upon chemical concentration, temperature and time.

Obviously, the most accurate test results are obtained where a prototype part is subjected to conditions which parallel the proposed conditions of actual use. Where this is impractical, however, it is generally possible to predict whether the plastic will stand up in use, using ASTM D543-56T test method.

During this environmental test, in which the plastic is immersed in a test reagent for a period of seven days, the test part may be affected in a number of ways. It may change in size or shape, in color or weight. It may craze, crack, or lose gloss; and strength and stiffness may be reduced. However, the primary measure of chemical sensitivity is the rate of weight increase of the sample. Test effects, combined with visual observation, yield considerable information on probable in-use performance of the plastic.

The data presented in the table below were obtained using the ASTM D543-56T test method, except that the recommended immersion period was extended from 7 days to 4 weeks. The test temperature was 75°F., representing ambient conditions.

Data in the table were developed using pure reagents. Where plastics will be exposed to proprietary compounds, usually formulated over a wide range of chemical compositions, results may vary. In such cases, it is recommended that tests be carried out using the specific compound in question, to determine chemical resistance of the plastic. Chemical resistance tests should be made in the absence of vibration and stress. Even in cases where more severe applications are to be expected, these data are useful in determining whether actual service tests or trial installations should be made.

Environmental test data developed by Dow Plastics Technical Service Engineers are available to designers and plastics engineers in all fields of plastics application. For detailed information on these studies, write THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Department 1733EX6.

GENERAL CHEMICAL RESISTANCE CHARACTERISTICS OF SOME DOW PLASTICS

Test Temperature—75° F. Test Period—FOUR WEEKS

CHEMICAL CLASS	DOW PLASTICS MOLDING MATERIALS						
	Ethocel®	Polyethylene	Saran	Styron®		Tyril®	Zerlon®
	—	Types I, II & III	—	General Purpose Grades	Impact Grades	—	—
Acids, Inorganic							
weak	E	E	E	E	G	E	E
strong	P	E	E	E	G	G	NR
strong oxidizing	P	G	G	F	F	NR	NR
Acids, Organic							
weak	E	E	E	E	E	E	G
strong	F	E	E	F	G	NR	NR
Alcohols	NR	E	E	E	G	F	NR
Aldehydes	NR	E	G	NR	NR	NR	NR
Amines							
aliphatic	E	E	G	E	E	E	E
aromatic	E	E	P	NR	NR	NR	NR
Bases	G	E	G	E	E	E	E
Beverages	G	E	E	E	E	E	E
Condiments	G	E	E	G	G	E	G
Esters	NR	G	E	NR	NR	NR	NR
Foodstuffs	E	E	E	E	E	E	E
Glycols							
polyglycols	G	E	E	E	E	E	E
polyglycol ethers	NR	E	G	NR	NR	NR	NR
Hydrocarbons							
aliphatic	NR	NR	G	NR	NR	E	F
aromatic	P	NR	F	NR	NR	NR	NR
chlorinated	NR	NR	G	NR	NR	NR	NR
Insecticides	NR	G	F	NR	NR	NR	NR
Ketones	NR	G	F	NR	NR	NR	NR
Oils							
essential oils	NR	F	E	NR	NR	NR	NR
vegetable oils	E	E	E	G	G	E	G
Pharmaceuticals	G	E	E	E	E	E	E
Salts	G	E	E	E	E	E	E

E—Excellent, unaffected.
G—Good, slight discoloration. Expected life of the plastic, months to years.
F—Fair, moderate discoloration or dimensional change. Expected life, weeks to months.
P—Poor, considerable change. Expected life, days.
NR—Not recommended. Severe attack.

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THE DOW CHEMICAL COMPANY DOW Midland, Michigan

SPE JOURNAL NEWSLETTER

reading time
1 minute

Vinyl Synthetic Leather

Vinyl foam production may get a considerable boost in the near future, the result of several processes for making expanded vinyl sheeting. Du Pont is marketing a blowing agent trademarked Nitrosan, which is mixed with a poly-(vinyl chloride) plastisol, then later activated by heat to release nitrogen gas, the blowing agent. A pilot unit to demonstrate the process was shown last month at Waldron-Hartig. Naugatuck Chemical Division of U.S. Rubber has a similar process, this one using a blowing agent trademarked Celogen-AZ. Presently, there are 8 processors marketing this expanded sheet material.

New Copolymer

A new copolymer has joined the resin family—ethylene and vinyl acetate. Called Elvax by Du Pont, it will be produced at that company's new plant at Orange, Tex. The new resin is expected to increase the use of wax in the paper, packaging, adhesive, and other industries where wax is now used. The new plant will also produce high-pressure polyethylene, bringing Du Pont's over-all polyethylene capacity to nearly 400,000,000 pounds.

Polyethylene Latex

First commercial polyethylene latex will be produced by Spencer Chemical Co., approximately January 1962. Spencer is building a 20-million pound plant at Calumet City, Ill. This is the first time that polyethylene has been offered as an emulsion polymer. In the floor polish field, for example, the polyethylene increases the life of the polish without decreasing such properties as gloss, slip resistance, removability, and resistance to water spotting.

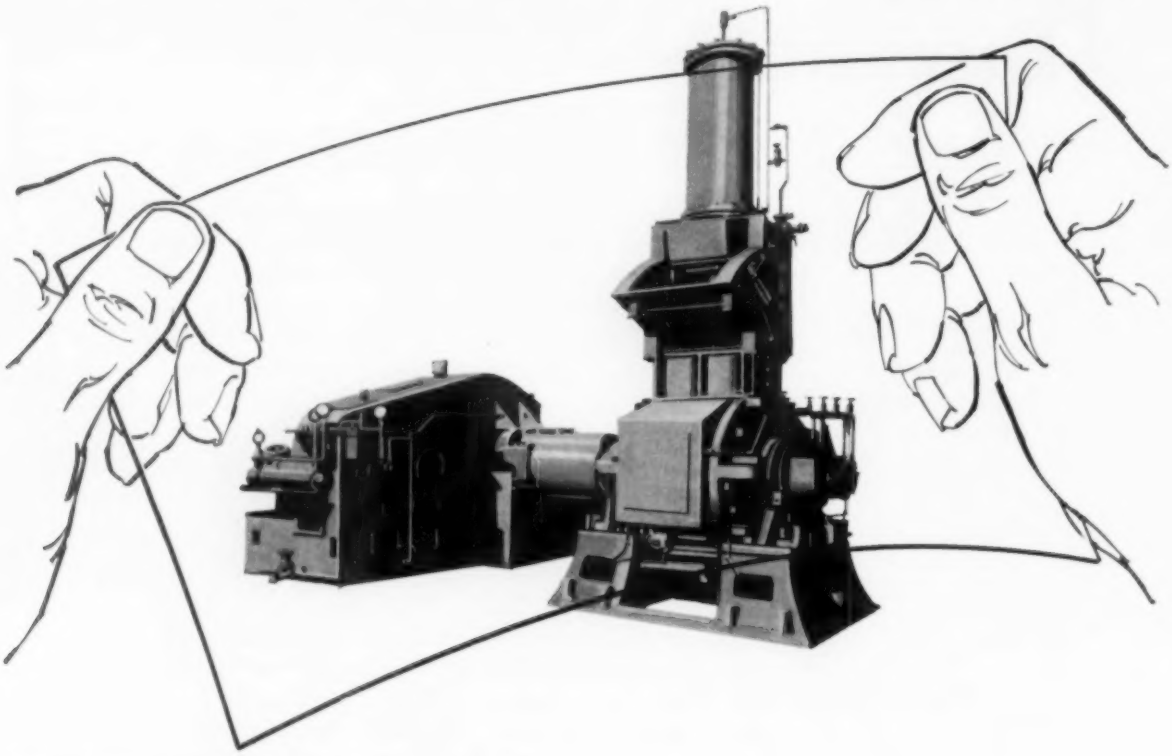
Carload Lots for Small Processors

Unloading equipment just developed by Whitlock Associates may make possible carload purchases of resins by small processors. The newly-developed equipment operates in the range 1000-8000 pounds per hour and can be coupled in with inter-plant conveyance systems, right to the machines. Price range is $3000-$6000, compared to $12,000-$25,000 for available equipment.

New Copolymer

Refractory metals may play a part in developing very high temperature resistant polymers. In an article to be published in the third quarterly issue of SPE TRANSACTIONS, it is suggested that niobium and tantalum may be combined as copolymers with phenolic derivatives to give the heat-resistant resin.

A SKILLED HAND IN CHEMISTRY . . . AT WORK FOR YOU



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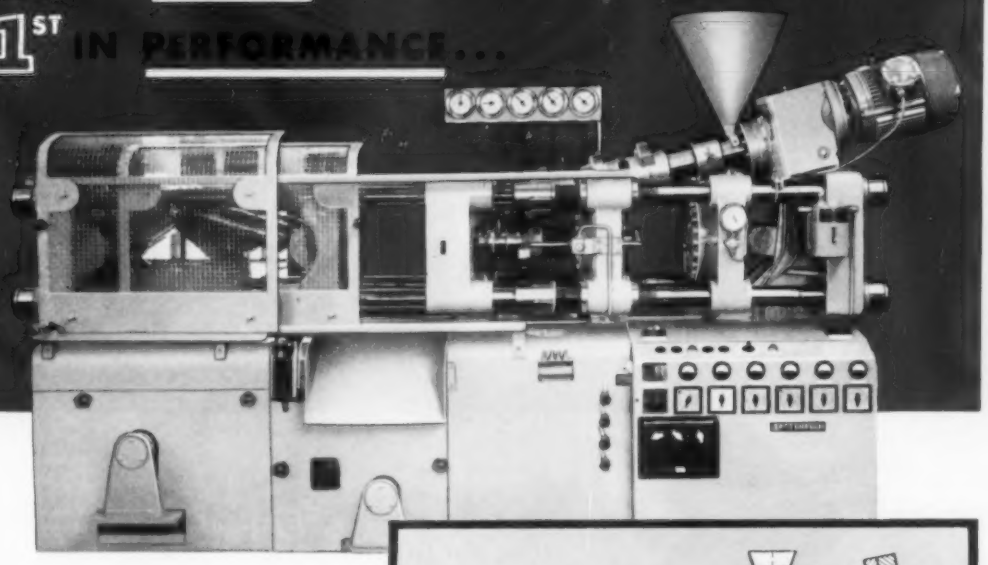

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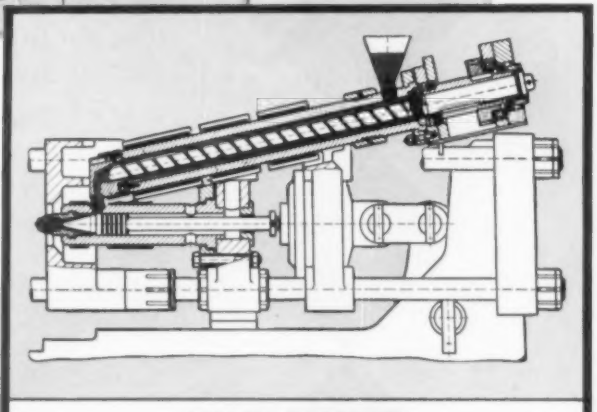

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Panels for this building were coated and fabricated by Elwin G. Smith Company, Pittsburgh, using "Strip-Gard" strippable vinyl coating made with Geon vinyl by Stoner-Mudge Company, Pittsburgh, a Division of American-Marietta Company. It can be applied by all standard methods including brush, reverse roll, spray, dip, flow and conventional roll coating. B.F.Goodrich Chemical Company supplies the Geon vinyl.

Here's a temporary coating that goes on metal fast, strips off easily. Meanwhile, it gives polished, embossed or coated metals protection during fabrication, storage and shipping. It's an organosol based on Geon vinyl.

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Because it's made of Geon, the coating protects metals from the effects of oil, grease and from discoloration or etching of corrosive chemicals. It provides excellent resistance to scratching or abrasion. The manufacturer says it's not designed to protect against weathering, but it will—tests show no staining or embrittlement outdoors for periods up to six months. And the desirable stripping qualities are not impaired.

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Geon VINYLS

Special Feature

Movable Screw Plasticizing Boom?

A. R. Morse, President,
Injection Molders Supply Co. Inc.

In October, 1960, two SPE members, Edward J. Haskins and A. Reynolds Morse spent 5 weeks visiting injection molders and injection machine manufacturers in England, Germany, Switzerland and France. The following article is adapted from talks given by Mr. Morse to the Cleveland and Denver Sections of SPE on movable screw injection machines. Mr. Haskins is Chairman of the RETEC to be held on December 1st, 1961 in Cleveland on the subject of screw type injection molding machines.

American molders got their first look at movable screw injectors at the Dusseldorf Fair in 1959. It is doubtful if they realized then that within twelve months plunger type injection machines would be passé in Europe. In order to assess the implications for American injection molders and injection machinery manufacturers of such a complete revolution in fundamental design, this article takes a close look at movable screw plasticizing trends in Europe.

It is not easy, in the midst of a tremendous screw plasticizing boom such as the European press makers are now experiencing, to get a true perspective. The entire foreign injection machine industry seems hypnotized by an aura of unparalleled success, and a wide variety of screw injector designs are all being rushed to market at once. European molders have been quick to recognize the many advantages of the movable screw principle and the European press manufacturers have found that plunger presses can now be sold only in backward countries. Business is so good that at present (January, 1961) delivery on the better screw injection machines range from 12 to 20 months.

Some Reservations

Long observation, however, has shown that several years are required to work out the kinks involved in *any* press design change, much less one as radical as the complete elimination of the heating cylinder. What reservations we have about movable screws are based nof on the fundamental principle of screw preplasticizing, but on the feeling that not all of the many different methods proposed for eliminating the old style high pressure plunger and heating cylinder can possibly be equally successful.

The "wait and see" attitude of many American injection molders appears to be very wise. There are many practical reasons why the screw injector caught on so quickly in Europe. It seems premature, therefore, to conclude that plunger molding will be made obsolete in America.

The few prototype movable screw injectors already installed in this country are giving evidence that they are better for specialty applications on thermally difficult materials than for general purpose high-speed molding as commonly done in this country. Late model American injection machines equipped with top-notch heating cylinders should still give movable screw injection some stiff competition, and prevent complete upheaval in press design concepts such as swept the European industry in 1959-60.

ECONOMIC FACTORS

Limited Resources, Lower Press Speeds

The basic differences in economic conditions in Europe and America have influenced injection press design.

American press manufacturers have been hopelessly involved in a tremendous horsepower race, to achieve high injection speeds at high pressures. The vicious product copying and price-cutting which most American injection molders must face have spurred the demand for such high speeds. We have always taken this competitive situation in our stride. The day may be approaching, however, when our press makers will have to reconsider such wasteful practices as building into all their injection machines high speeds and other costly features which benefit only 1%.

American injection machines have proven far too liberal for limited European resources in their use of electric power and cooling water. Copper is scarce and costly abroad. Power circuits in Europe and other parts of the world cannot handle the peak overloads generated during the few seconds of injection on modern American machines.

Incoming and outgoing water lines are quite limited in size. Because American plastic manufacturers mold much larger areas, our mold cooling techniques and platen sizes have been far ahead of foreign competition. Now European platens have been enlarged, but our copious use of mold cooling water is simply unheard of in many plants there, a reason why they do not need faster cycles.

To achieve a 15 to 20 per cent reduction in oil cooling water consumption one European manufacturer

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even takes the risk of using a pressurized water heat exchanger for cooling the hydraulic oil under high pressure. This gives relatively small increase in cooling efficiency. It should be noted that some foreign design oil coolers would give real trouble in American hard water areas, and that many are inaccessibly located on the press.

With some exceptions, then, European press makers have not sought the ultrasonic and futile dry cycle speeds now claimed by many American press makers. Their two basic considerations in design seem to have been, first, the maximum feasible speed at which their client's molds could be run, and second, the building of a good solid machine that would run for a long time without any service costs. It is of paramount importance to note that 50 to 80 per cent of their total press production is exported. The cost of breakdowns in Bombay, Sao Paolo, or even Toronto (if your manufacturer is located in a remote small town on the continent) can be excessive.

Quality vs. Quantity

The emphasis in European injection moldings has always been on quality rather than quantity. There is a far wider use of heavier wall sections, thicker rims, and so on. A heavy duty bucket or pail, for example, might have a $\frac{3}{8}$" wall section, with a $\frac{1}{2}$" bead, or top rim, weigh nearly three pounds and sell for about four dollars. Even the cheaper line of dishpans seldom have sections approaching ours in thinness. The surface luster of articles like bowls seemed to indicate that either the European molder was getting a much better molding polyolefin, or else the screw injectors were, in fact, producing a superior product. The use of plastic in toys was comparatively limited. Most injection molded articles were utilitarian or industrial.

The high quality of European injection molded articles has been possible for two reasons. First, is the continuous postwar European recovery boom, and second, the fact that "cheap" merchandise lines and the flimsy "one-shot" merchandizing schemes that have, unfortunately, flourished here in America, just won't go over with the thrift-minded European consumer.

The heavier European molded parts are produced on longer cycles in lower cost molds and can be sold at lower cost than most American injection molded goods. The European operator works for 50 to 70 cents an hour and often tends up to four injection machines. This one thing makes their lower plasticizing rates and slower press speeds economical. In addition, the European manufacturer serves a smaller volume market and has much lower distribution costs.

Movable Screw Injector Suits European Needs

The Continental prosperity of 1957 and 1958 led to the desire among European manufacturers to undertake the transition to bigger molding machines. The American piggy-back approach was ruled out, like many other American innovations, by economic realities, for which we seem to have a flagrant disregard. The power units needed were far too costly, and the heater loads far too heavy for Continental use.

One solution to the power problem was originally found, of course, in the use of accumulators. Many European injection plants still operate very efficiently on central hydraulic systems, even using water in some cases, and can equal or exceed the speeds of our more costly self-contained machines at far lower first press cost and operating expense.

However, the movable screw injector unit provided a more feasible method of matching European presses to the limited power and water facilities available abroad. The screw eliminates the costly dual hydraulic cylinders of the American piggy-back system and keeps less material in process than dual heat chambers. Leakage and contamination from the shot cylinder are also done away with.

The pioneers of movable screw injection systems must have foreseen its advantages. By eliminating nearly all of the pressure losses arising from pushing directly on cold granular material with the injection plunger, press horsepower could be sharply reduced. By generating enough frictional heat with the screw, the power requirements could be cut by comparison with standard heating cylinders of equivalent capacity. And finally, by combining the separate screw and plunger of the basic Hendry system of the early 1940's, they could eliminate material transfer, confine leakage to the inside of the cylinder, and offer a single compact mulling and injection unit. It is still somewhat of a mystery why for fifteen years movable screw injectors went relatively unnoticed.

Obsolete Heaters—Many older European injection machines employed extremely backward and often inefficient heating cylinder designs. This undoubtedly helped to spur the quick changeover to movable screw injection systems. Full-size, fully-rated up-to-date heaters are not inexpensive items, and as much radical revision of older press designs would be required to convert to a modern heating cylinder as to a completely new movable screw injector housing.

Press manufacturers seemed to feel however, that the advantages of the screw were so obvious that, even had their heating cylinders been as advanced as ours, the screw injector would still have taken hold as rapidly as it has.

Type of Materials Molded—The fact that low cost rigid PVC materials and polycarbonates have been available for years in Europe has also aided the rapid rise of the screw injector. The very low watt density heat used on screw type injection cylinders plus the active mulling action of the screw combine to melt most heat sensitive plastics with minimum decomposition.

Ordinary vinyl, because it can be host to additives which are often unsuited to ordinary injection molding heats (and now the acetal resins, because of their tendency to decompose into somewhat toxic gas) are also easily handled by screw injectors.

Competitive Situation

U.S. Market—The most startling thing about most foreign injection machines (next to their remarkable workmanship and finish) is, of course, their low price. This is possible mainly because of the low labor costs ($0.60 per hour for ordinary and $1.00 per hour for skilled labor) and the greater productivity which may be demanded from European workers. On the basis of price *alone* European press makers might be able to capture a good part of the American new press market by 1962.

This competition has not been so keen until recently because the European press makers have been too busy supplying such places as Sweden, China, South America, India, and Ceylon. But now this demand is slowing up and, simultaneously, plant expansion programs (often financed by the United States) are nearing completion. German, Italian, and English press makers are now turning their attention to the American market.

The cost of a completed, European-made machine with advanced electronic programming devices, which permit continuous checking of the operating cycle on illuminated circuit panels, is 1/3 to 1/2 lower than the equivalent American press. Even with duty and freight paid and a good assortment of spare parts, a foreign injection machine can be set down in New York *at 1/4 to 1/3 less than our own delivered press cost.*

This price advantage is somewhat offset by long press deliveries due in

part to acute shortages of steel, castings, instruments, and skilled machine shop labor, as well as designers, and electrical and hydraulic experts. In addition, it is possible that there will be a high mortality rate among present screw injectors. The "cheap" molds from Europe might be kept in mind. In several cases the reworking necessary to adapt such molds to our advanced production requirements has cost more than the imported tools themselves.

Export—Perhaps an example will illustrate how extensively foreign manufacturers have captured the export market. Nearly 80% of Injection Molders Supply Company inquiries based on advertising come from foreign countries. A recent follow-up on such a query from Jamaica revealed that they already had on hand two 2-oz. machines, two 4-oz. machines, one scrap grinder, and thirty molds. The molds were for such items as combs (six cavities), tumblers (one and two cavities), brushes, small housewares, and low-cost toys.

The injection machines were copies of English ones. They had Vickers pumps, made in England, German electrical equipment, solenoids, timers, and so on, and Swedish electric motors, and they had been assembled, in Hong Kong by labor costing about $0.30 per hour. The entire cost of this equipment was $30,000 U.S. dollars. An equivalent purchase here would come close to $144,000. With press operators receiving $1.00 per day and air freight from Jamaica to the U.S. at 6¢/lb. the impact of these low costs is obvious.

It is estimated that last year the 18 American injection press makers produced about 1100 presses of all sizes. Only 60, just over 5%, were exported, while foreign press makers export 60–80% of their output.

American Position—The introduction of the movable screw and the low labor costs and resultant low prices of foreign presses undoubtedly present American press makers with important economic and technological problems. Content to supply good general purpose injection machines for polyethylene and polystyrene, we have been slow to perfect specialty screw plasticators.

Few objections to foreign-made presses remain. Many already use standard Vickers hydraulic equipment; European solenoid, control, and timer manufacturers are planning to stock component parts in America. Other press makers are arranging for their parts suppliers to put in inventories here in order to give overnight service anywhere in the U.S.A. There is little departure from the metric system as yet, but American standard threads can be had on special order for extended delivery.

The American competitive position may be strengthened by the development of American-made counterparts and by planned continuous mulling and degassing replacement units which may be installed in existing machines without radical alteration of the injection end.

Several of our major press makers have already made license and other agreements, and 1961 will undoubtedly still hold numerous surprises on this score. However, with the great number of possible design variations on the movable screw, far more than can be visualized for the plunger machine, American press makers might do well to wait for some of the inevitable problems to be worked out.

Until the European (and Japanese) laborer has a standard of living and wages more comparable to our own, American manufacturers in all fields will be faced with stiff price competition from imports. This situation is certainly contributing to the "balance of payment" problem about which we have heard so much lately. Reduction of taxes paid by American business and higher import taxes on items such as injection presses, where the competition is especially keen, could ease matters for our manufacturers and aid the national economy.

TECHNICAL FACTORS

Basic Screw Injector Cycle and Design

The Screw—The injection screw is much simpler in design and principle than the conventional extruder screw. The majority had an LD ratio of 20 to 1, or more. Tapered and compound designs were rare and the average screw seemed to have a two to four inch flight with a thread depth of 3/16 to 1/2 inch. The principal variations were in the tip and it was obvious that a color weeping or weld was occurring on the screw tips. Twin screws, especially, seemed to have a dead spot at the tips.

The friction of the turning screw provides part of the necessary plasticizing heat. As the screw turns, the heated and unheated layers of plastic are mixed in the flights and the plastic is carried toward the nozzle, where it finally fills a space or chamber. The pressure of the material advancing along the screw and filling the storage chamber causes the screw itself to move back in the barrel, since the screw is spline-driven.

In the typical screw injector, the actual injection is done by pushing on the rear of the screw, with either a separate or connected hydraulic piston. The screw itself acts as the injection plunger. Since the screw is then returned by the pressure of the plastic accumulating in front of it, the material can be kept under continuous pressure.

Many variations of this basic floating screw design were observed. In one machine the screw is held stationary while the barrel and its entire housing move back under the pressure of the plastic accumulating in front of the screw. In another, the screw retracts, but the material also forces an auxiliary shooting plunger up. The plastic is injected into the mold by this side-acting piston, which has its own independent storage chamber above the screw discharge space. This design is identical to Impco's "second stage" injector, except that a movable screw does the plasticizing. The purpose of this design is to provide more hot plastic storage space, so that a lower cost, shorter stroke screw can be used.

Nozzles and Valves—If a shutoff valve is used, the screw can turn at any time during the cycle. If there is no nozzle shutoff valve, the screw can turn only during the cooling cycle when the nozzle hole is blocked by the cold sprue.

A nozzle pull-back is often used to break the sprue and to prevent nozzle chilling by heat loss to the mold. This movement of the injection end housing has long been eliminated from the American cycle, but in several screw designs it is necessary. While it provides a source of nozzle and sprue bushing peaning and breakage, the pull-back conveniently actuates the nozzle shutoff valves, especially if they are of the internal type.

Nozzle separation, therefore, was more often used than not. This indicates that cold nozzles are a common problem and also that some screws could not provide high pressure fast enough to blow out the cold slug.

Both sliding port valves and rotary valves are used for nozzle shutoff. Sometimes they are actuated by separate small hydraulic cylinders and sometimes by solenoids. In other cases they are built into the nozzle, have an external spring, and are moved by a small third platen as the die closes, or by moving the whole injection end housing.

Internal valves, often of the sliding ring or ball type, are used to prevent pressure loss back along or through the screw. Obviously, these one-way checks must allow the plas-

tic to flow into the storage chamber and then close when the screw makes the injection stroke. They must be self-cleaning or easily removed for cleaning.

The internal and nozzle shutoff valves seemed to be a source of costly maintenance and downtime unfamiliar to American molders.

Shot Size—This is strictly limited by screw travel and displacement, and screw travel is always relatively short, primarily because it is an expensive factor in machine design. Therefore, extra capacity is much more costly to achieve because stuffing shots cannot be taken.

Attempts to offset screw stroke limitations are made by offering several different diameter screws for the same press. Both the screw and the barrel liner must be replaced, but usually the tube OD and heater band sizes are left constant in order to reduce the cost.

The different screws, of course, operate at different pressures. For example, a 1½-inch diameter screw might have a 6-inch stroke and be rated at 20,000 psi and to ¾-oz capacity. When increased in diameter to 1¾ and 2 inches, pressures may drop to 15,000 and 11,000 psi and capacity would rise to 5 and 6½ oz., respectively. However, the practical range of work is correspondingly reduced, just as larger plungers often reduce piston machine efficiency.

Thus, the capacity of a screw machine is limited almost exactly by the press specifications. Any changes are either expensive or impossible.

Press comparisons are likely to be extremely misleading, because of the effect of variations in screw diameter-to-length ratios. Variations in press performance are of even more concern, because of the wide differences and efficiencies of the drives which turn and push the screws.

Feed—Feeding the movable screw is simple because weighing is not necessary. The feed may be of the crowd type or the batch type. The most common was an open feed direct from a hopper, with the screw determining its own intake by its flight design, speed, depth of land, and so on.

Starved feed screws with batch or weighed feed and valving to regulate the material density and discharge rate offer an interesting area for experiment.

Auxiliary Plasticizers

A screw extruder may be mounted to discharge directly into a shooting cylinder, or even into the parting line of a mold held in either an injection or compression clamping device. Many molders have failed to distinguish between such screw preplasticizing and the movable screw injection unit.

Unless the shooting device has a movable screw it offers nothing more than the American piggy-back system. Choice between the two becomes simply a matter of economics.

To date the screw has proven cheaper when installation costs are considered. Volume-produced screw melters will soon be available from a German manufacturer. The molder need not rebuild his machine for a piggy-back. He needs only a ball check valve, a shot cylinder and plunger, and the screw plasticator wheeled up beside his press.

Ratings

The friction of the turning screw generates part of the plasticizing heat and therefore screw injectors supposedly have lower wattage requirements than injection cylinders. Because the screw usually does not turn during the entire cycle its potential efficiency is lower than it might be. This partially accounts for variation of the estimates of adiabatic heat generation from 20% to 80% of the total needed.

Little appears in the literature on the "how and why" of screw plasticizing. Research has been concentrated on maintaining a constant pressure in the nose of an extruder, but the transitional melting phases in which injection molders are most interested have been neglected. Injection molding with a sliding screw is different from extrusion and much study is still needed on screw plasticizing in theory and practice.

There is also wide variation in estimates of the capacities of different screws. Rating and displacement techniques have been worked out by painstaking calculations and tests by most European press makers. However, about the only constant factors appear to be elimination of the bulk factor problem and reduction of the shot output to a definite number of cubic inches. The many variations in barrel length, band wattage, screw design, internal tolerances, speed, and effective injection pressure, as well as the controversial frictional heat, serve to make the published ratings ambiguous. Several years of education are needed to translate the ratings to our terminology and accepted methods.

American heating cylinders are now more often underrated than overrated The 1960-1961 injection machines are closer to their top ratings than ever before. This is clearly demonstrated by their inability in many cases to take smaller shots, while oversize shots are easily run.

The capacity of a movable screw injection machine also depends, of course, on the kinds of material being molded and varies just as it does with a heating cylinder. For example, a screw rated at 120 lb./hr. on polyethylene might do 60 lb./hr. on vinyl, 45 lb./hr. on rigid PVC, and 150 lb./hr. on medium impact styrene.

The effect of the insulating properties of thermoplastics in reducing heat input efficiency has often been completely neglected in heating cylinder design. It is obviously time to consider the specific heats of thermoplastics in designing and in determining plasticizing capacities. This becomes especially important in working with the screw plasticating principle.

Clamp Size and Injection Pressure

Movable screw injectors are supposed to do as much or more than piston machines. Therefore, the European manufacturers are advertising greater clamping areas, larger platens, and heavier clamps, realizing that greater clamp pressure and overall rigidity are necessary to take full advantage of the movable screw.

The injection pressures have not been too sharply cut either. It is very interesting that the ratio of clamp to injection pressure apparently must remain about the same as on plunger machines in order to avoid molding difficulties. When larger diameter screws are used to increase shot size, the injection pressure is deflated, and the same problems arise as with plunger machines in the 11,000-17,000 psi range.

This seems to indicate that a constant will soon be found which will allow rating of the viscosity and resistance of the melt to injection pressure (whether applied by a screw or a plunger). Such a constant should also allow appraisal of the net effect of frictional heat derived from small nozzles and gates. Most important of all, it will probably be found that pressure losses on piston presses are not nearly as large as have been thought.

Sinks, worm tracks, and other signs of inadequate injection pressures were observed in Europe, and recently in this country. Pressure losses in movable screw machines, both normal and from wear inside the screw housing, are apparently going to cause molding problems. Twenty thousand psi remains a reliable pressure for good injection molding, even with the best preplasticizing method.

At 20,000 psi screw injectors give mechanical problems. Either the pressure losses must be overcome, or improved, movable screw design for molding at 20,000 plus psi must be developed.

Screw and Barrel Design

The variations in screw design were many. Efforts are being made to come up with a universal flight pattern. At present, most concerns agreed that at least two basic screws should be used, one for rigid PVC and the other for general purpose resins. Some recommend a third type for polypropylene.

Conventional degassing features, increased pressure stages, and all the costly variations found in extruder screw systems are also offered. It is still an open question, however, whether these features are necessary for a sliding screw used as a plunger.

Probably the widest variation was in the length-diameter ratios. The differing adiabatic heat estimates have caused some press makers to shorten screws and reduce wattages, while others are lengthening them to increase plasticizing efficiency.

An almost unlimited number of screw tip designs was also observed. They range from relatively sharp points for vinyl and rigid PVC to blunt rounded, or even concave, plunger tips for other materials. For effective purging the nose of the barrel must change in design with the screw tip. Holdup patterns here may cause just as many marks and strains as are found in a heating cylinder, because they are introduced *after* the screw has done its mulling work.

Twin screws have certain advantages, for they can be made shorter than single ones. However, their cost is comparatively high and there is still the problem of gathering the material at the twin tips with hangup in the dead space in between them.

Screws with high speeds of 300-1750 rpm offer interesting possibilities. Screw speed should become more important to injection molders than to extruders.

Barrel designs were also quite varied. Removable liners and bolted on front ends seemed to be the most common. Several straight nitrided tubes of unit construction with flange mountings were also in use.

Cooling provisions for barrels and screws were absent except in some cases where the barrel was cooled in the feed zone. The screw housing itself and the feed area were often cooled. The mechanical problems of cooling a movable screw are more complex than in cooling a common fixed extruder screw. There was a disagreement on whether cooling or heating will be needed in the future. As screw efficiency is increased, some kind of heat removal may be desirable.

Mica or radiant heaters using open wires mounted in ceramic bars with polished metal reflector covers were the most common. Two, three, or four zone heat controls were used. Nozzle or front end heats were individually controlled in some cases and hooked into the front zone in others.

It is important to be able to clean out the barrel and screw easily. Much ingenuity has gone into the various and often quite elaborate mechanisms for screw removal. Perhaps color changes in movable screws may not be as quick and trouble-free as is claimed.

Many tough metallurgical problems are still present, although plating and various degrees of nitriding, and bushings and barrel liners are used commonly to minimize galding and lengthen screw life. It was demonstrated that metal and tramp particles are usually carried through to the nozzle. Wrecks are still costly especially if the drive is involved.

A nozzle shutoff valve allows the screw to turn for a much longer part of the cycle. Therefore, this feature affects basic screw design, speed, and length-diameter ratios, as well as plasticizing capacity.

Special purpose dispersion nozzles and various types of nylon shutoff nozzles with internal or external springs, or with pressure-actuated valves operated by the pull-back of the injection end housing were observed. This pull-back, usually not used in American molding, indicates that nylon does tend to drool from the storage chamber in front of the screw unless somehow restrained between cycles. The nozzle shutoffs, with their spreaders, webs, seats, and sliding fits are also a serious source of strains and streaks. Such devices, because they follow the screw and leave patterns of orientation similar to those found on piston type presses, thus undo much of the good mixing done by the screw.

Drive Design

Two basic types of screw drives are found: direct motor drive through ears, and hydraulic motors.

The direct electric motor drive is much the cheaper, but there are several major objections. It is positive, but it requires good electrical as well as mechanical protection to avoid sheared screws and galded barrels. Its most obvious drawback is its limited speed range.

The hydraulic drive has variable speed by means of a Vickers or other servovalve and can be set, for example, to turn from 2-50 rpm. Slippage is automatic, providing low-cost, built-in, foolproof safety.

Neither chain belt nor positive drives along with v-belt drives were in evidence, possibly because they were unwieldly and ill-adapted to a housing which must slide itself as well as contain a rotary motion. When the more elaborate drives begin to age and fail, the simplicity of a v-belt drive may be wished for again.

In some cases the screw can be set to turn continuously at a slow speed (thereby increasing plasticizing efficiency). But in other cases the screw can rotate only during the mold cooling, just after injection. It must then be turned at a higher speed in order to fill the storage chamber without taking extra cycle time. In another design, the screw can turn during the injection cycle itself because a splined construction permits both rotary motion from the screw drive and right-left motion from the oil piston to be transmitted on the screw at the same time.

The back of the screw in one press was nothing more than a simple bumper plate which was pushed by the face of the injection plunger. This actual physical separation of the push of the plunger from the rotation of the screw seems advantageous. Only a forward push is required by the plunger; it is pushed back by the turning screw. Regulation of the oil cylinder discharge to the tank controlled the resistance offered by the plunger in order to maintain full material density ahead of the screw.

The wear on splines and gears has yet to be assessed. Because of the intermittent screw loading, which reaches a peak once in each cycle, maintenance costs might be fairly high. Thus easy access to the screw drive becomes of great importance. Some presses appeared to be so overdesigned that they would be almost wholly impractical from a maintenance point of view.

Damage can be done by startups without sufficient heat to free the screw from cold material. Despite built-in safeties the screw can be twister, or the spline drive sheared.

Adaptation of U.S. Presses

Conversion to movable screw injection could be accomplished by removing the injection end of an American plunger press and substituting the screw injector housing assembly. However, there is at present no one unit which could be easily mounted on all American presses.

There is little uniformity in base length and designs. Cutting into the hydraulic and electrical lines might be feasible, but the cost of converting the machine back to piston molding would be prohibitive. Lining up the screw plasticizer with American platens would require elaborate and expensive adapter bases.

With overall European press costs so low and the art of the movable screw so new, the wisdom of virtually permanent conversion of a plunger machine to one type of screw injection is questionable. Careful analysis of the individual situation would be necessary. For specialty applications, however, where press time and costs are wholly secondary, conversion might be justified.

It is doubtful that a "conversion kit" can be supplied at reasonable cost. The alteration expenses would be greater than the screw assembly itself. At present, purchase of a whole new press seems preferable. Press attachments cannot compete with the 30-40% margin available on new presses to cover sales, service, warranties, and other contingencies.

Patent Situation

Basic differences in American, English, German, and Italian patent laws cause some complication in the patent situation on screw plasticators. Additional confusion results from the fact that new screw injector designs have been brought out faster than the patents can issue. It is difficult to know what is or soon will be covered. Practically, the situation should be similar to that of blow molding.

Probably the most interesting patent to date is the Ankerwert-Willert patent covering the basic concept of the movable screw. Several press makers are already licensed under this patent. Other companies are expending a good deal of ingenuity to get around it by such methods as using a fixed screw and moving the barrel.

Because of the tremendous amount of prior art and the good sense of machinery makers in using informal conferences, extensive litigation on screw injector patents does not seem likely. What patent issues do arise will undoubtedly revolve around specialty items like double screws, shutoff valves and methods of removing the screw and barrel for cleaning.

Pros and Cons

Many advantages have been attributed to movable screw plasticators. The mulling action gives a rotary motion to the plastic along with better mixing, lower decomposition rates, better degassing, and quicker color changes. Spreaders and other expendable heater parts are absent, pressures are supposedly lower, shots bigger, color dispersion is improved, and all materials, including polycarbonates and rigid PVC, may be handled easily.

Quick startups and easy shutdowns were demonstrated and there were few rejects when production was interrupted. The melt was simply stirred up, shot into the mold, and the press was back on cycle with no burning or black specks.

However, movable screw injectors are still relatively unproved. Movable screw presses are offered in such a variety of designs by so many firms with such different backlogs of experience that the price should not be the paramount consideration in purchasing one. It should also be remembered that with screw injection goes a good deal of costly re-education in mold design, gate design, and venting, and in operating techniques.

Among the reasons which may be given for holding back on movable screw presses is the need for more study of the many unsolved technical problems involved in screw plasticating. The varying estimates of adiabatic heat seem to be leading different press makers in different directions. The result is specialty machines of limited application, not the universal press the American molder expects.

The design of screws and barrels and their maintenance, internal finishes, tolerances, nozzles design, wattage—in each of these areas there is considerable difference of opinion and potential costly sources of trouble. It would, for example, be an advantage to have a universal screw design.

Other problems lie in cycles so long that American molders would be driven to distraction, and in the intermittent turning of the screw. The material may rest unmulled just as long in a screw injector as in a plunger machine. Furthermore, the material stored ahead of the plunger also is static for a large part of the cycle. In order to keep the material in continuous motion, provide more efficient heating, and improve plasticizing the screw should turn continuously. Before this can be achieved nozzle valves simpler in construction and operation will be needed.

One of the chief limitations of screw injectors is their relatively fixed specifications. The integral construction with the power units of the barrel and screw makes modification of the press almost impossible. Little can be done to change the effective rated capacity from that of the screw and barrel supplied by the original press maker.

An indication that screw injectors do give some trouble was observed in commercial moldings which had an unacceptable number of sinks, along with ripples and other signs of low pressure. In some stores seconds were being sold at reduced prices.

While screw machines can be useful for specialty applications, particularly with thermally difficult materials, late model piston machines still appear to be the most economical for jobs requiring high speed or close dimensional tolerance.

However, in the screw-plunger concept there is something far more fundamental than past problems like the growth of vacuum forming or blow molding. This year will be a decisive one for the future of basic injection machine design as the screw plasticating principle moves rapidly into the press picture.

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Author's Note

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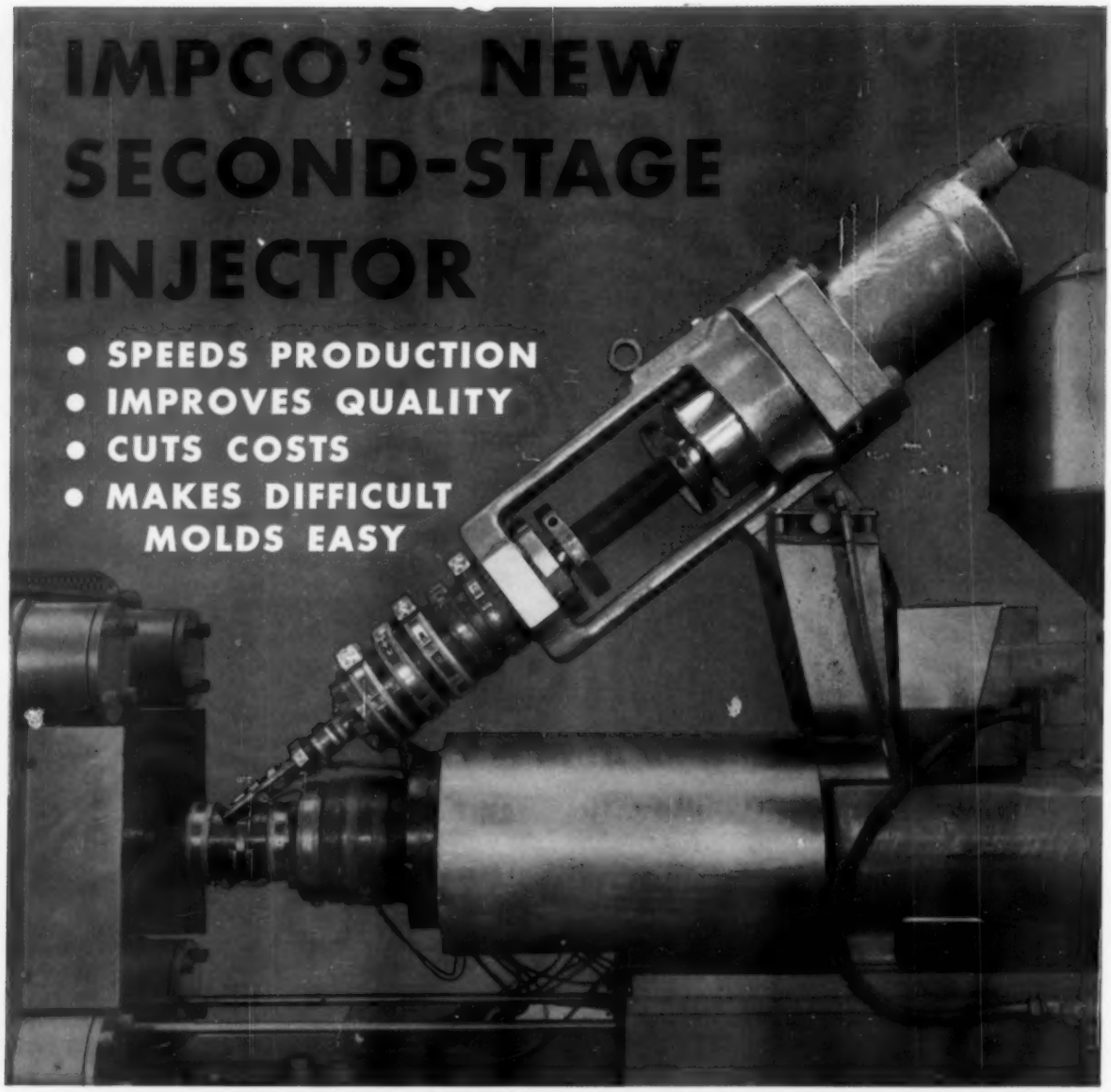

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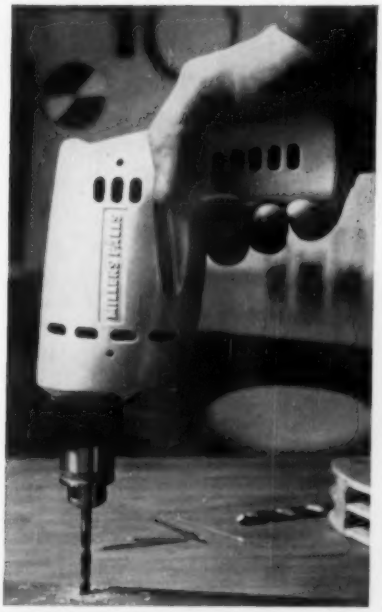

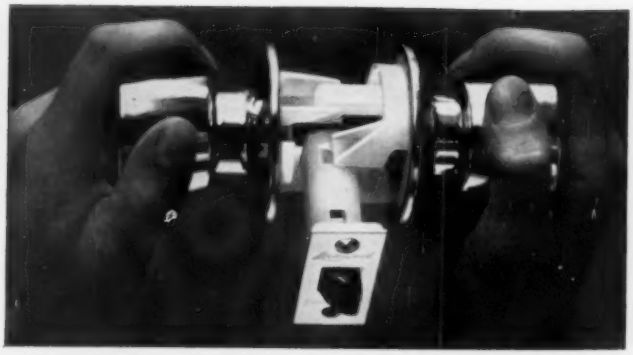

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The sharp increase in advertising activity and expanding editorial program of the Society has made it necessary to increase both the editorial and advertising departments. The addition to our sales staff will make it possible to give more service to current and future advertisers. The new addition to the editorial staff will assist in developing material towards more effective SPE publications for members and subscribers. The new appointees are shown below.

S. Patrick Johnston has been appointed to assist Lee R. Noe, our Advertising Manager, in covering accounts in the Eastern territory. Mr. Johnston has long been associated with industrial marketing, analysis and product promotion. Married, and the father of two children, his hobby is aviation.

Louis Naturman has been appointed to the position of technical editor for the SPE Journal and SPE TRANSACTIONS. Mr. Naturman has recently been associated with the consulting organization, Aries Associates, where he was primarily concerned with doing economic analysis and market research for the CPI. He is a chemical engineering graduate from McGill University and holds an MBA degree from the Wharton School of Finance, University of Pennsylvania.

ADDITIONAL PERSONNEL ANNOUNCEMENT—**Donald J. Catron** has joined Raymond B. Mooney & Associates, SPE Journal's representatives for Ohio-Eastern Michigan, Western Pennsylvania and Kentucky. A graduate of Tulsa University, Mr. Catron's most recent position was that of an advertising account supervisor with Electric Autolite Company. In his present post, he will be directly responsible for accounts in Ohio and Kentucky. He is an active member of the Toledo Chapter of the American Marketing Association.

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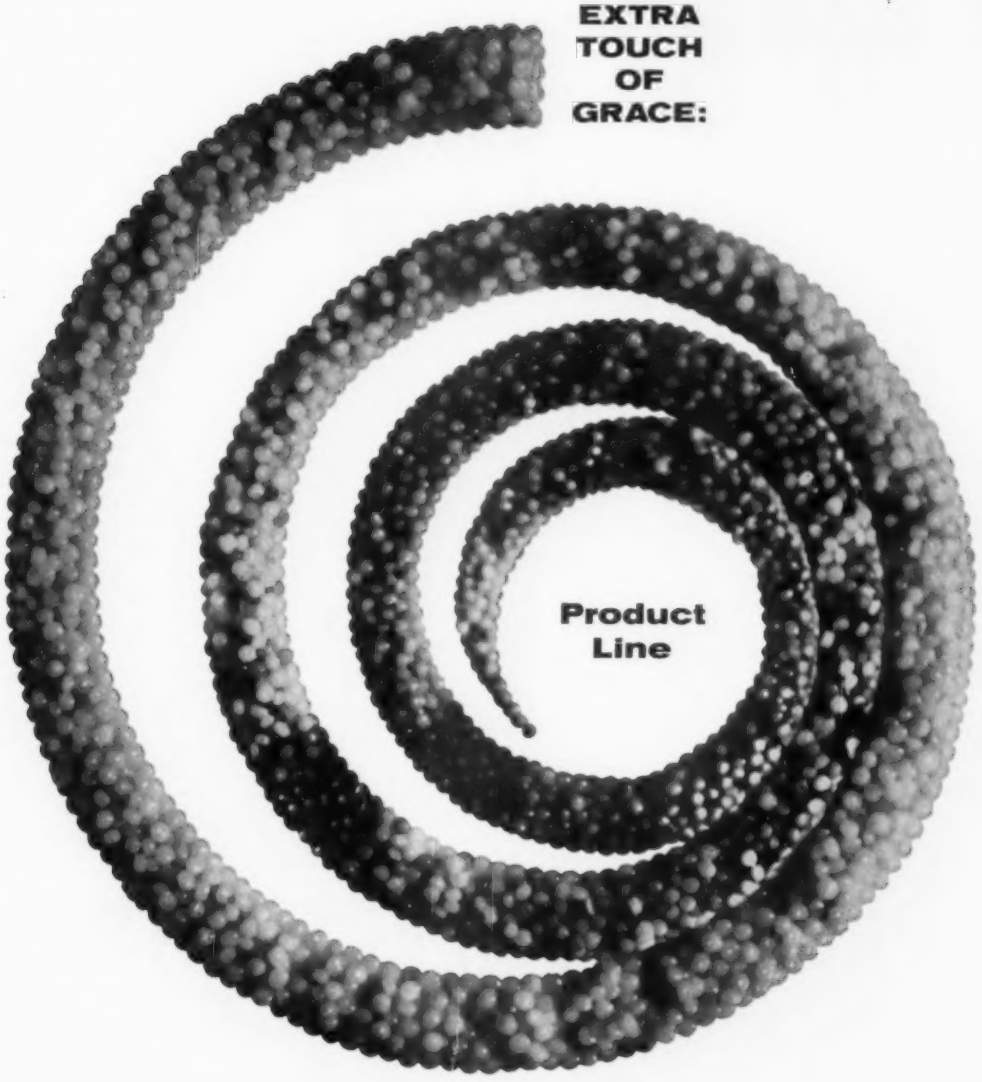

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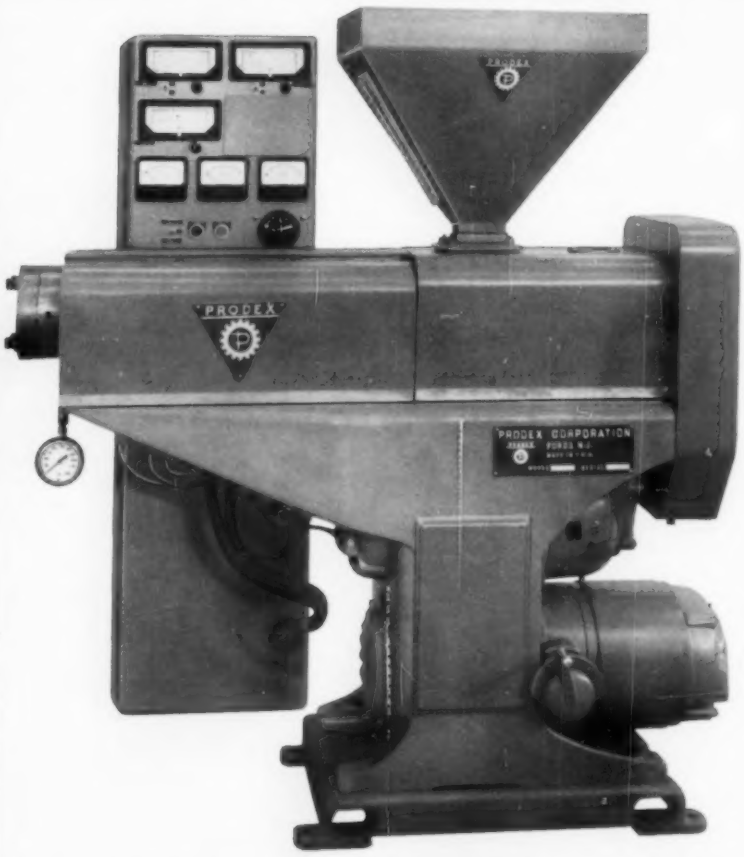

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Extrusion Bibliography

This bibliography was compiled by the PAG on Extrusion under the direction of the chairman, Mr. L. F. Street. The former two lists presented in the July 1959 issue of the Journal were divided under the headings of "Extrusion Theory and Analysis" and "Extruder Design and Application". They have now been combined into a single list, and brought up to date. The reader will have a more convenient means for reviewing pertinent literature in the extrusion field

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Bruce H. Maddock
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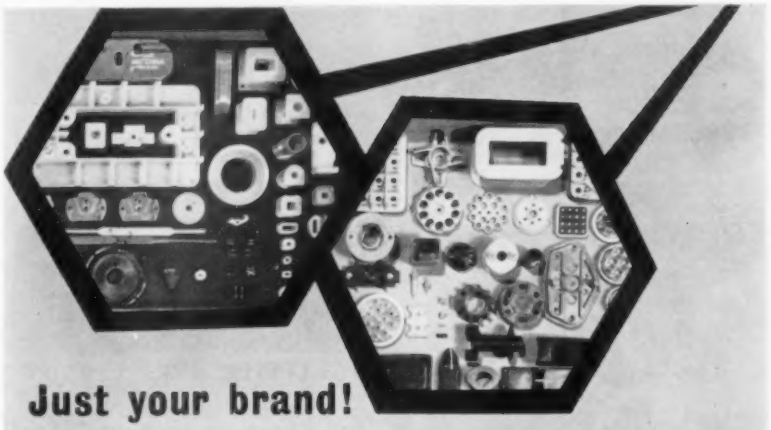

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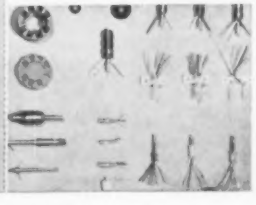

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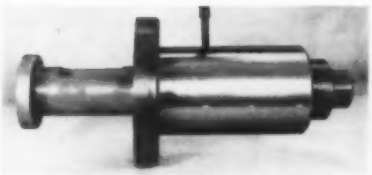

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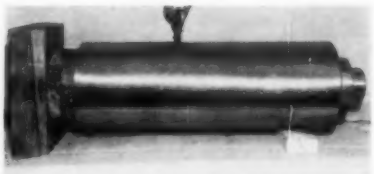

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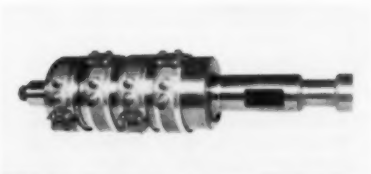

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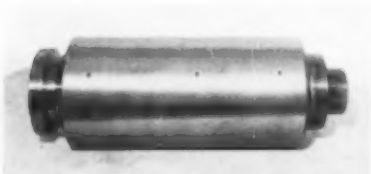

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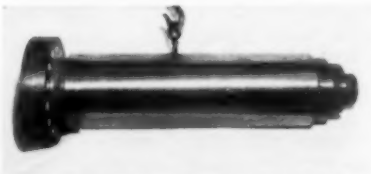

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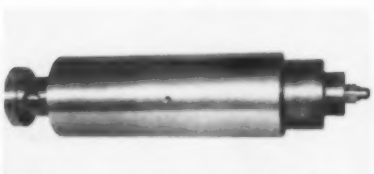

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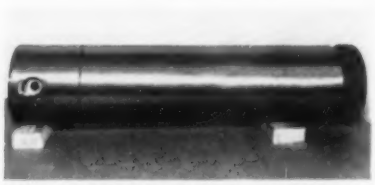

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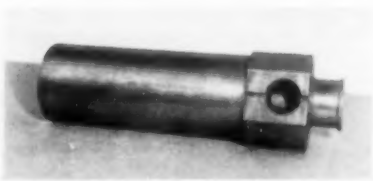

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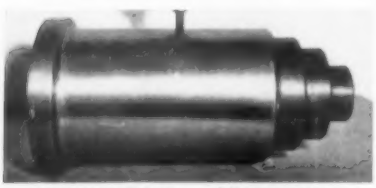

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In the molding of temperature-sensitive materials it is very often discovered that the cycle required to mold the part is shorter than the time required for heating the material at a safe temperature in the cylinder. As a typical case, the molding of unplasticized PVC demands control of the maximum temperature to which the material is exposed. To avoid overheating, the cylinder temperature must be kept below the breakdown point, but at this level the rate of heat transfer is low and if a large heating cylinder is used compared to the shot size, the inventory time in the cylinder is increased to an unsafe point. A second objection to the use of oversize cylinders is that there is a ratio that must be maintained between shot size and inventory time that would require changing cylinders for every job.

To determine the most practical method of controlling the safe hold-up-time in the cylinder a study of the heat transfer characteristics of a small cylinder was made. The normal shot size of the cylinder without prepack was approximately 21 grams but with prepack it was brought up to 34 grams. The inventory capacity was 126 grams or 6 normal shots, or 3.7 prepack shots.

A Case History

A sample job run under straight cycling called for a one minute cycle but the cylinder could not keep up with the plasticating required. Running this same job on a larger machine resulted in breakdown conditions with the result that the cylinder had to be purged too often to be economical. If the same job were put back in the smaller cylinder and run at a slower cycle, it would be impossible to remove the part because of excessive shrinkage. In addition the stresses set up during the long cycle caused warpage and reduced strength.

The machine was altered to permit cycling of one minute but a one minute hold-up or mold-open dwell was added to the cycle in order to give the cylinder time to catch up with the molding. Under these conditions perfect parts resulted and the cylinder was purged only at the end of a day's run. No breakdown was experienced and the flow of material required relatively low pressure. To analyze the behavior of the cylinder a study of the effect of inventory time was made. Six other jobs of varying size were tested with identical results. The use of a varying dwell time rather than an increase in inventory capacity produced an acceptable production whereas any change in capacity that would not permit control of inventory time produced breakdown and lost production.

Examining the rheological characteristics of unplasticized PVC it was found that a change of 25°F at the operating or flow point of the material produced little change in its flow behavior but the change in temperature was sufficiently great to produce serious breakdown and decomposition. This would clearly indicate that there was no advantage gained by increasing the melt temperature but rather a danger of breakdown resulting from effectively an increase in temperature gradient. The heat transfer behavior shows that a longer time at a lower temperature will produce a more thorough melt condition without the danger of overheat. The conclusion then was that overheat and decomposition could best be avoided by keeping the temperature at the lowest point permitting flow but not above a temperature which would afford absolute safety for the time needed to produce complete melt.

Practical Mathematical Approach

The relationship between hold-up-time and temperature can be expressed mathematically by a study of conductivity, specific heat, density, and a number of other related factors, all of which vary from material to material. It is perhaps simpler to establish a rough approximation in order to determine the order of magnitude for future detailed study of similar molding conditions. A convenient form of this approximation is

$$M = \frac{K}{(H - C)^n} \qquad (1)$$

where M = hold up time (minutes)
K = constant for the system
C = constant for the material (°F)
H = safe operating temperature
n = exponent of function relating material to system and having an approximate range of 1 to 3

For a set of conditions where n = 2, C = 300, K becomes 10^5 (see chart).

CHART FOR DETERMINING HOLD-UP TIMES AT VARIOUS SAFE OPERATING TEMPERATURES (H)

H	M	H	M
300	0	400	10.0
320	250	420	7.0
340	66.7	440	5.0
360	27.8	460	4.0
380	16.7	480	3.1
		500	2.5

The relationship of hold-up-time to inventory and cylinder capacity is

$$M = \frac{225\ V}{R} \qquad (2)$$

where V is inventory in ounces and R is cylinder capacity in pounds per

Continued on page 622

At Eastman you can find plastics to shape a new world of products

Ideally suited to modern high-speed vacuum-forming techniques, Tenite plastics are cutting costs sharply for many manufacturers

Vacuum forming—one of the oldest techniques of fabricating plastics, but only in recent years adapted to speedy modern methods—is now in the foreground of interest as an important method of shaping plastics products for today's market.

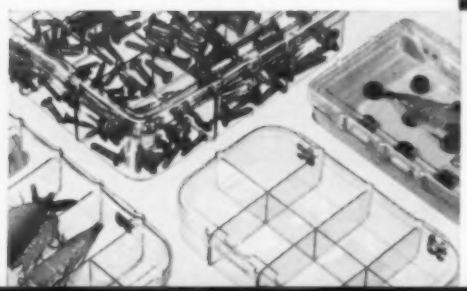
Starting material for a vacuum-forming operation is an extruded thermoplastic sheet. In simplest terms, vacuum forming involves only two steps, both performed on the same machine. The first step consists of clamping the flat sheet of plastic in a frame above the waiting mold and heating it (with built-in heaters) to the required forming temperature. In the second step, the heated sheet is brought down into close contact with the mold, suction is applied, and atmospheric pressure then forces the heat-softened sheet over and into the contours of the mold.

Sheet extruded from any of the Tenite plastics is well-suited to vacuum forming. Typical commercial products made of these plastics are shown on these pages. They illustrate the diverse shapes and uses to which vacuum forming can be adapted. An outstanding advantage of the Tenite cellulosics—Tenite Butyrate, Tenite Propionate and Tenite Acetate—is their low specific heat which speeds both heating and cooling. Sheet of these plastics can be formed quickly and economically into tough, lightweight, highly impact-resistant products of enduring luster.

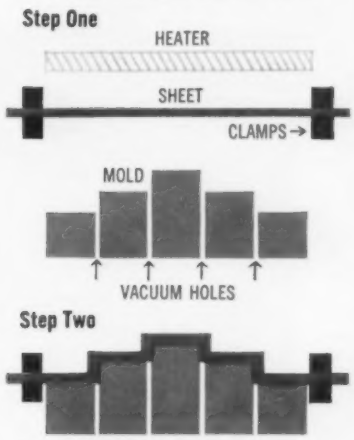
For products that are to be used outdoors, special formulations of Tenite Butyrate are available which provide excellent weather resistance and dimensional stability.

Tenite Polyethylene and Tenite Polypropylene are other Eastman plastics useful in vacuum forming. While slower to heat and cool than sheet of the cellulosics, these can be more satisfactorily formed in molds with sharp angles and offer many physical and chemical properties useful in housewares, industrial products, toys and packaging.

All Tenite plastics are available in a virtually unlimited range of colors. Over the years, the Tenite Color Laboratory has developed formulations in almost 43,000 different colors and color effects. For many applications, colored sheet can be used to yield an integrally colored product, eliminating the need for a separate decorating or painting operation. In other applica-



HOW VACUUM FORMING WORKS



NOTE: The above diagrams depict a simple vacuum-forming operation. There are many variations of this method, including some in which air pressure or mechanical pressure replaces the use of a vacuum.

tions, such as signs, clear-transparent sheet may be used, with the decoration being applied either before forming (by use of distortion printing) or after forming. It should be noted that even shapes which at first appear impossible to vacuum form can be produced by this method. For example, by using a "plug-assist" (to permit a deep draw), wastebaskets 8½" in diameter and 11½" deep have been vacuum formed from sheet of Tenite Butyrate. Similarly, spherical globes for toys and outdoor lanterns have been produced at low cost by vacuum forming two hemispheres and then solvent-cementing them together.

An important advantage of vacuum forming is the low cost of the necessary molds... often only 1/20th to 1/10th as much as those for injection molding. As a matter of fact, very inexpensive molds can be cast from plaster or tooled from hardwood or pressed wood to use on test runs, developmental designs, or single or short-run production.

The obvious economies inherent in vacuum forming have helped the technique win quick favor in many fields. In the manufacture of outdoor signs, displays, toys, housewares, decorative and lighting panels, vacuum forming is now a leading production method.

Vacuum forming also makes possible the rapid packaging of merchandise in bubble, blister or skin packs. Here, short heating and cooling cycles are particularly important because of the high speeds at which the packaging machines operate.

Perhaps vacuum forming with Tenite plastics could help you cut costs or speed production of some item you are now making or planning to make in the future. We'll be glad to help you explore its advantages and evaluate its merit.

The comprehensive story of how Tenite plastics are being used in this new manufacturing process is told in a 20-page booklet, "VACUUM FORMING." For your free copy, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENN.

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(Note that we say "flow rate." We hesitate to use the term "melt index" for polypropylene since the ASTM Standards, Section D1238, clearly define this term as a measure of flow at 190° C. under a load of 2.16 kilograms—the conditions generally reserved for measuring the flow of polyethylene.)

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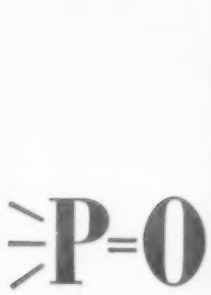

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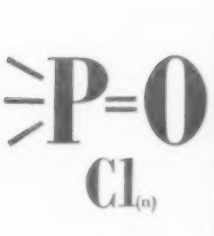

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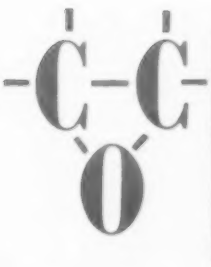

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SPE JOURNAL

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Orientation Characterization in Plastic Film and Sheet

A simple and rapid method for measuring orientation stress in film and sheet

C. T. Hathaway, *Monsanto Chemical Co.*

Conventional, unmodified, atactic polystyrene has a normal tensile strength of 6-7000 psi and is quite brittle. With orientation, the tensile strength jumps to 9-12,000 psi and the brittleness vanishes. This enhancement of properties is accomplished without any chemical modification. The polymer is heated above its glass transition temperature, Tg, and, while rubbery, is stretched to introduce orientation. By chilling while still under tension, this orientation is retained at room temperature. Typical changes in tensile strength are shown in *Figure 1*.

Most, if not all, polymers are similarly influenced by orientation. And the influence of orientation extends to tear strength, thermoforming properties, sealability, etc., as well as tensile strength. Orientation Stress (OS) measurements have been found most useful for characterization of this orientation (1). The reasons for selecting OS and the apparatus and procedures utilized are presented using polystyrene and tensile strength changes as examples. The general applicability of OS is discussed with presentation of measurements carried out on a wide variety of plastic films.

Shrinkage, Birefringence and Tensile Strength as Measures of Orientation

During the stretching operation, the molecules are shifted into relative alignment from the preferred random coil entanglement. If the material is reheated to the stretching temperature, the molecules will attempt to return to the preferred random coil entanglement.

This shrinkage on re-heating is sometimes used to characterize orientation (2, 3). Data presented in *Figure 1* illustrates why such shrinkage measurements may be misleading if not properly interpreted. Each sample biaxially stretched 200% will shrink to the same degree, e.g., from a 3" square to a 1" square with proportionate increase in thickness. Yet the tensile strength ranges from 7 to 10,000 psi and varies almost linearly with stretching temperature, Tp, over the range studied. Thus, while shrinkage may be quite useful for detecting the presence of orientation, it is of little value in determining the degree of orientation unless stretching temperature is known.

As mentioned previously, in oriented materials the molecules tend to be aligned in preferred directions. In fiber technology this orientation is strictly uniaxial along the length of the fiber. Birefringence measurements or viewing with crossed Polaroids can characterize this orientation very satisfactorily. If film and sheet were elongated in only one direction it would be comparable to a group of fibers laid side by side and fiber birefringence techniques could be applied directly. However, this type of orientation has little practical significance since such a material would crack or break very easily parallel to the direction of orientation.

Practical film and sheet are oriented biaxially by stretching in two directions. When such film is examined normal to the surface birefringence merely indicates the difference in orientation between the two directions. Since this orientation is usually intentionally balanced, the measurement is of small differences between two large numbers where this difference is of little interest, but the magnitude of the large numbers is essential and unknown.

Ideally, the sample should be observed from the edge—a very difficult feat with 1 mil film. Dr. Richard S. Stein of the University of Massachusetts has used a technique of measuring birefringence at a series of angles and mathematically extrapolating to the desired edge view (4). The skill required, complex calculations, and number of observations needed preclude this technique for routine tests.

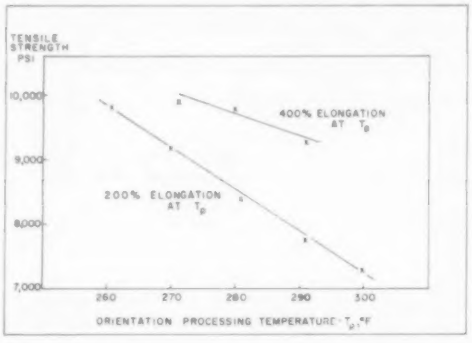

Figure 1. Enhancement of room temperature strength through orientation is a function of both temperature and % elongation

Tensile strength suggested as a measure of orientation quickly reaches a plateau and undergoes little change despite substantial further orientation, *Figure 2*.

Orientation Stress—OS

Orientation stress has been called by many names, unmolding stress, relaxation force, orientation release force, thermal retractive force, internal stress, shrinkage force, to mention a few. The ASTM had used orientation stress, but lated adopted orientation release stress. Orientation stress or OS is used here. It refers to the force, or stress in pounds per square inch of cross-section, with which a heated sample tends to return to its pre-orientation dimensions.

The importance of orientation stress was pointed out by James Bailey of Plax and others (5). From *Figure 2* it is seen to be a result of the interaction between elongation and the stretching temperature—a given value of OS being obtainable under various combinations of processing temperature and percent elongation. (Since orientation was intentionally balanced in the machine and transverse direction, only one point is plotted in *Figure 2* for each test.

Mr. Bailey used an apparatus such as shown in *Figure 3* (6). It consisted simply of an appropriate heat source and glycol bath, clamps for the sample, and a lever arm system to indicate forces applied. Mr. Bailey's preliminary design demonstrated remarkable insight. With utter simplicity, *the* critical property was characterized by holding a sample over a candle using a metal shield to protect the flame and, incidentally, the fingertips.

ASTM D-1504 was based on the Bailey apparatus described in (6). Following normal ASTM practice, neither the apparatus nor the heating technique used are prescribed in detail. In our initial work, an Instron tensile tester was used. R. D. Andrews, then at Dow and now at MIT, has reported similar work with polystyrene monofilaments using an Instron and hot air heating (7). OS measurement does not require the full capabilities of the Instron; in particular, the precision drive of the moving crosshead is not used. A special inexpensive instrument could then be built.

The Orientation Stress Analyzer

The apparatus as it evolved for us is shown in *Figure 3*. The sample is mounted between two clamps with the upper clamp supported on a load cell (Statham Gl-80-350) in a rigid frame. The channel on the lower part serves as a convenient guide for positioning the heaters. These are simply two Chromolox strip heaters so mounted that when they are slid in place one is about ⅛" behind the sample and the other about ⅛" in front.

Figure 4 shows a modification of this apparatus in which

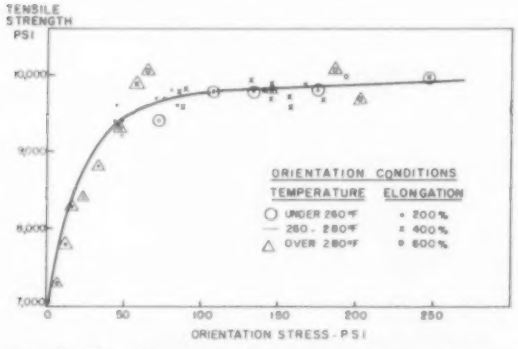

Figure 2. Tensile strength at room temperature vs. OS for film and sheet oriented by 200, 400 or 600% elongation or stretch at temperatures from 320-300°F

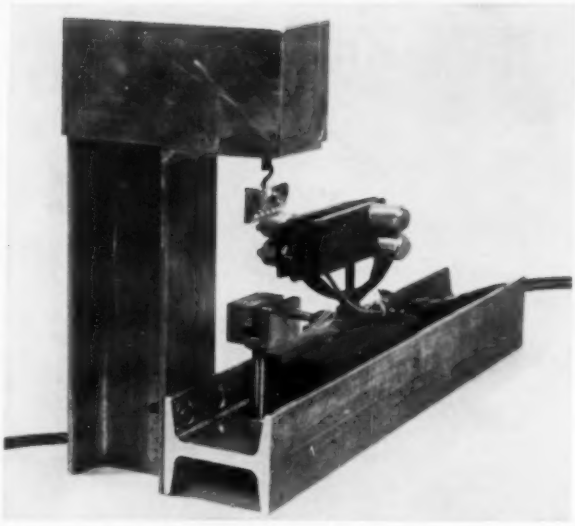

Figure 3. Orientation stress analyzer. Sample in place between clamps with radiant heater ready to slide into position

the lower jaw is supported on a strut so that the sample may be immersed in a liquid bath as required for many of the tests to be described.

Figure 5 shows the electrical controls for this device. At the left are a powerstat and pyrometer for control of radiant heater temperature. The pyrometer indicates the surface temperature of the heaters—not the sample temperature. A more elegant control proved unnecessary.

At the lower right are various calibration and zero adjustment controls. On the extreme right is a range dial which is placed in the circuit to compensate for the thickness of the particular specimen. Properly set, OS is read on the meter directly in pounds per square inch.

The amplifier consists of a 12 volt 60 cycle bridge supply, a two stage pre-amplifier, and a feedback and output amplifier. The 60 cycle unbalance from the load is rectified and displayed on the output meter. Controls for zero and quadrature null are standard on a.c. bridge circuits. Calibration is adjusted by the feedback gain based on a resistor switched across one bridge arm. Adjustments for varying sheet thickness (gauge) are made with the calibrated range dial. The potentiometer used must be calibrated empirically. A shunted center top spreads thickness values more uniformly over the 10 turns of the dial, but not linearly enough to avoid this calibration.

A small, but measurable, non-linearity of the meter rectifying network was compensated by compressing the stress lines on the lower 10% of the meter. An accuracy of ±2% was obtained over ranges of 2-20 mil film and zero drifts amounted to less than 1% over an extended period. These variations are well within those of other parts of the test. However, this amplifier could be improved upon in a number of respects. For example, the characteristic of output insensitivity to input phase gives a positive meter deflection for either compression or tension. This has not been troublesome, but in some situations could be a significant disadvantage. Important advantages of this system are low cost and an accuracy consistent with that of the temperature coefficient of the load cell. A commercial unit put on the market recently (Bytrex Corp., Newton, Mass., Model 470) could be used as a building block in an Orientation Stress Analyzer suitable for ASTM.

Operation. With the upper jaw in place the system is zeroed and calibrated either by dead weight or by switch-

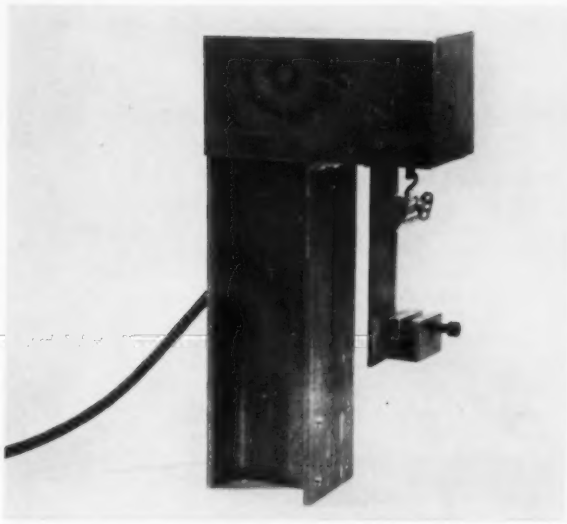

Figure 4. Orientation stress analyzer. Clamps mounted for heating by immersion in a liquid bath

ing a fixed resistance into the bridge circuit. Direct reading of OS in pounds per square inch is obtained by setting the range dial for the exact gauge. (An empirical table of dial-setting vs. gauge is used. Direct reading in gauge would be possible but expensive.) The heater is moved into position and the peak reading on the meter recorded as OS in psi. The entire test rarely requires more than one minute.

Sample Heating Techniques

ASTM procedure D-1504, which was only in draft form at the time this work was started, does not specify the heating technique, but states merely—"Any means of heating the test specimen which maintains the temperature uniformity of the specimen within ±1°C".

Difficulties were encountered in comparison testing with other laboratories and even in the reproducibility of our own work. Variations of up to 25% were not unusual. Therefore, an investigation of several heating techniques was undertaken.

Figure 6 shows representative curves selected from several hundred tests. The traditional method is gradual heating in a glycol bath. Starting around 190°F, there is no signal until the bath rises to about 200°F. In the next 10° rise the load increases rapidly, ultimately reaching a peak at around 230-240°F and recorded as the Orientation Stress.

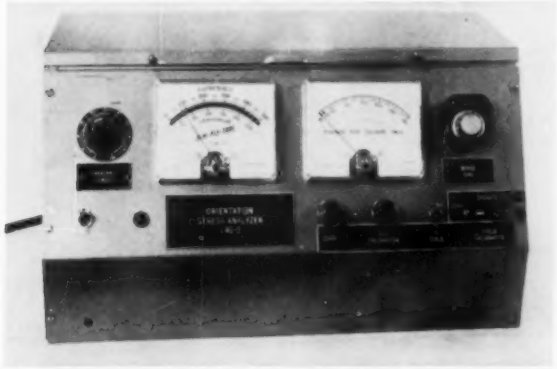

Figure 5. Orientation stress analyzer control panel with heater power control, pyrometer, OS meter, range dial and controls for zero and calibration

In view of the need to run hundreds of specimens, the 5-15 minutes required for cycling the bath temperature was prohibitive. Therefore, direct immersion in a constant temperature bath was investigated.

The upper three broken lines indicate typical results with bath temperatures of 320, 284 and 230°F. A peak is reached quickly and subsequent decay is rapid. Both the rate and the value of the peak drop off as lower bath temperatures are used. Presumably some relaxation takes place before the peak is reached. The curve at 212°F is an extreme case, taken to show this partial relaxation during the 10-12 minutes required to reach that peak.

Radiant heating seemed particularly attractive because it would approximate commercial use in thermoforming sheet and would eliminate the hazards of handling the hot glycol. Results indicated as solid lines in *Figure 6* were rather similar to those with direct immersion, but higher in value and more rapid in response.

The temperatures cited, 347, 302 and 257°F, represent the surface temperature of the heater and not the sample temperature. In all tests where continuous records were obtained, the peak or OS value was reached at a sample temperature around 230°F. The method of heating apparently determined only the time required for the sample to reach that temperature (230°F) and, presumably, the amount of relaxation which might occur before this peak.

In a further investigation, these three heating methods were compared under conditions as indicated in *Table 1*. Values are for specimens cut from a single sample of 10 mil, oriented polystyrene. The three groupings represent gradual heating, direct immersion and radiant heating. Questionable values are given in bold face. Reproducible values in regular type. For gradual heating in the glycol bath, values tended to be low at a rate of 3°F/min., but were reproducible at higher rates. The maximum rate, 24°F/min., represents the practical limit of the heating system available. A "reproducible" range average was 253 ± 6 psi.

Direct immersion gave low values at 220°F as might be expected. This may be compared with the load vs. time response at 212°F in *Figure 6*. From 230° to 270° results appeared to be quite uniform, averaging 255±4 psi. At higher temperatures, erratic results were obtained, the samples practically disintegrating on immersion.

Low values for gradual heating and direct immersion are attributed to partial loss of orientation during the lengthy heating period—partial annealing. In contrast, the radiant heating technique gave erratic, high results at heater temperatures below 320°F. This is believed to be due to momentary cooling of portions of the specimen. Thermal contraction on cooling produces forces at least an order of magnitude larger than OS forces. Momentary convective

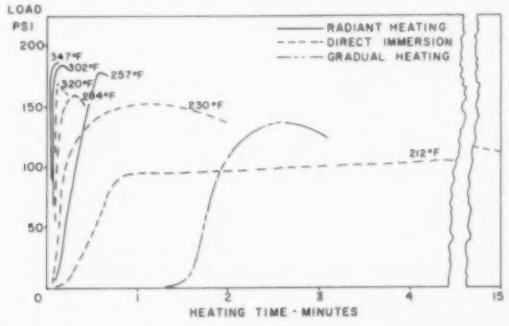

Figure 6. Typical load vs. heating time curves for various heating procedures. OS, taken as peak value, generally is lower at lower heating rates

Table 1. Comparison of OS Values Obtained by Various Heating Procedures*

Gradual Heating in Bath		Direct Immersion in Hot Bath		Radiant Heating	
RATE °F/MIN	OS PSI	BATH T °F	OS PSI	HEATER T °F	OS PSI
3.3	***232***	***220***	***248***	***290***	***277***
3.7	***240***	***220***	***223***	***290***	***287***
6.8	253	230	256	***300***	***290***
6.9	263	230	251	***300***	***256***
18.7	244	240	255	***300***	***285***
19.0	254	240	258	***310***	***285***
21.0	255	250	255	***310***	***298***
24.0	248	250	246	***310***	***275***
		250	255	***310***	***281***
		260	249	320	255
		260	259	320	265
		270	259	320	268
		270	260	330	256
		280	***278***	340	271
		280	***266***	360	253
		280	***258***	380	258
		290	***285***	400	264
		290	***278***	420	248
		290	***283***	460	260
		300	***310***		
		300	***288***		
		300	***296***		

* All specimens were cut from a single 10 mil sheet. Values in regular lighter type bold face show a standard deviation of 1.6 to 2.7% comparing favorably with the gauge uniformity 9.97 ± .14 mils or ± 1.4%.

cooling of even a small portion of the specimen would produce high loads which can be interpreted erroneously as OS.

With radiant heating, reproducible values were obtained from 320°F upward, 260±7 psi. Above 400°F the response is too rapid to follow except by high speed recording.

This comparison is not intended to say that any one heating procedure must be used, but merely to indicate the importance of adequately specifying the heating procedure. Reproducible results can be obtained with each technique. Radiant heating has been found to be most convenient—the apparatus may be kept constantly available and each test may be completed in less than one minute.

Table 2. Orientation Stress Values Encountered in Commercial Films and Sheets

Polymer	Heater Temp °F	Orientation Stress PSI
Ethylene—Low Density	350	0-1010
Ethylene—Med Density	350	0- 25
Ethylene—High Density	350	0-
Propylene	400	0-1200
Styrene	350	75- 300(1200)
Styrene—Impact	350	0- 200
Styrene—Acrylonitrile	350	75- 250
Vinyl Chloride	350	0- 125
Vinylidene Chloride	350	200- 400
Fluorocarbon	400	0-
Nylon	350	0- 140

Work reported here has emphasized transparent film and thin sheet, up to about 20 mils. Pigmented materials and heavier sheet respond to this test. However, heat transfer in such materials may present entirely different problems both for processes to introduce orientation and for tests to characterize orientation.

Orientation Stress in Various Polymers

Orientation stress measurements are by no means peculiar to polystyrene. The values cited in *Table 2* indicate the range of OS levels which have been observed in commercial film or sheet. In each observed case of intentional orientation, values of 75 psi or higher were found in both machine and transverse directions.

With polyethylene there is usually little or no attempt to introduce orientation. In the machine direction, low values of OS sometimes result from what might be regarded as excessive drawdown. With high density polyethylene, no intentionally oriented film has been encountered commercially. However, one would expect to be able to obtain values. Comparable values are expected with polypropylene.

Initial tests with polypropylene failed to indicate any orientation—even when known to exist. Raising the heater temperature solved this dilemma easily and values to 1200 psi have been observed. Thus, the heater temperatures in *Table 2* are not necessarily the optimum, but have proved satisfactory for screening. Further testing is indicated.

Polystyrene has already been covered; a low of 75 psi is indicated as the approximate threshold for obtaining optimum tensile improvement. Materials below this are a compromise with unoriented material. The maximum for most heavier sheet seems to be 300 psi. However, film has been observed with values as high as 1200 psi.

Impact styrenes do not require orientation to be useful as thin sheet but can have properties enhanced. Styrene acrylonitrile is comparable to unmodified polystyrene.

Both plasticized and unplasticized vinyl chloride can be oriented as, for instance, in shrink-type films. Vinylidine chloride films are normally oriented.

A recently introduced fluorohalocarbon film gave no indication of orientation when tested at 400°F. This does not prove that it was not oriented or that it might not benefit from orientation. Nylon was noted both with and without.

Conclusions

Orientation stress (OS) has proved useful for characterizing orientation in polystyrene plastic film and sheet. With the apparatus described, the measurements are made simply and rapidly. Both the introduction and measurement of orientation are highly dependent upon the temperature cycle used; therefore, the OS heating procedure must be carefully specified. OS tests have been extended to a wide variety of plastic film types.

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The Spray-Up Process — Promising Fabrication Technique

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Thinking of going into reinforced plastics fabrication? Here is a case history of a company—outside of the primary field of plastics—who did. It describes the reasons for the choices the company made, the process, and lists the advantages and disadvantages of the spray-up process. Their past experience could help your future thinking

This article describes the manufacture of resin-fiberglass reinforced machine housings, by the spray-up process. It was written to express the approach of a custom fabricator toward fabrication of reinforced plastics parts by this most promising process.

The company is principally engaged in the manufacture of textile finishing machinery. The parent company, Riggs & Lombard, was formed in 1932 by a group of men who saw the possibilities of the then new material—stainless steel—in the field of textile machinery. Now management is alert to the possibilities of another material in the same field—reinforced plastics. In 1958, as part of an expansion program, Riggs & Lombard purchased the firm of Parks & Woolson in Springfield, Vt. Parks & Woolson was established in 1826 and has long been known in the field of textile machinery, and like many other old and conservative firms had become the victim of old methods and habits. With the acquisition of the firm it was apparent that a modernization of methods and materials was required, as well as new products.

Initial Problems

One of the new materials investigated was fiberglass reinforced plastic. By definition, a reinforced plastic is a composite material with one continuous resin binder phase (thermoplastic or thermosetting) and a reinforcing fibrous phase for controlling the process, mechanical, and physical properties. This hybrid material appeared to have a great potential not only for Parks & Woolson but also for Riggs & Lombard, and its subsidiary, Cook Machine Company, who as fabricators of machinery of stainless steel had been constantly plagued by its increasing cost.

As the most pressing need was at Parks & Woolson and the personnel there had initiated the materials investigation, all work has been done at the Parks & Woolson Plant in Springfield, Vermont.

The first step was to review where the material could be most easily and effectively used. *It was obvious that some of the highly complicated and repetitive sheet metal work offered a good starting point.* The quantities were not large enough to justify adequate sheet metal tooling but were large enough to amortize inexpensive molds.

Initial work was done utilizing existing sheet metal fabrications as molds and conventional hand lay-up techniques. It soon became evident that three separate but intimately related problems existed: *Mold design, part design, and methods of fabrication.*

This article is concerned mainly with the method of fabrication, and alludes to the other two problems only as they affect the selection of the methods of fabrication.

Selection of a Process

The first and most basic method tried was conventional handlay-up utilizing fiberglass mat, cloth and woven roving with the resin being applied by the usual paint brush and bucket technique. This method had many drawbacks, among which were the following:

1. Forms of glass used were too expensive
2. Paint brush and bucket technique did not lend itself to the small labor force available, or to the high labor cost and low rate of mold turnover
3. The sheet materials did not lend themselves to the complicated shapes of the pieces

Figure 1. Step 1—A mold release is put on the mold to facilitate release of the finished molding from the mold

Figure 2. Step 2—A closeup of the spray-up equipment. Not shown are the tanks which supply resin under pressure to the spray gun. The operator is now ready to deposit the material on the mold

Figure 3. Step 3—The glass-resin mass has now started to cure—while the laminate is in the intermediate stage it has the consistency of jelly and may be readily trimmed with a knife

Figure 4. The completed piece after removal from the mold

THE SPRAY-UP PROCESS—ADVANTAGES

Adaptability to varied contour mold—the material as it is delivered to the mold is essentially nondirectional. Unlike sheet materials such as mat or fabrics, it adjusts to any contour without tailoring or the awkward handling encountered when trying to apply a large piece of sheet material. Not only does the material adapt to multiple contoured molds but it allows the high production of fiberglass reinforced plastics (FRP) pieces which are too large for ready adaption to matched metal dies.

Reduction of waste—because there is no tailoring of materials there are no odd shaped waste pieces. Tailoring time is eliminated altogether. Waste is limited to a small amount of overspray.

Lowest cost materials—resin is usually purchased in large volumes. Glass is purchased in its most inexpensive form, that is balls of glass roving, similar to that supplied to the manufacturers of the more common sheet materials used in hand lay-up.

Localized reinforcement—in nearly all pieces which have a structural requirement whether it is a simple guard or a large tank, there are areas which are subjected to greater stress than the rest of the unit. Because of the way material is delivered to the mold additional reinforcing can be obtained by the operator simply building up the thickness which blends in and tapers out into the rest of the laminate. One only has to look at photos of FRP storage tanks to see the visual importance of this type of reinforcing. Most tanks ribs are applied after the body of the tank has been completed and the reinforcing applied to hold the rib in place, always showing clearly that it was "added on". Similarly a variety of inserts can easily be introduced into the laminate by spray-up. The advantages work in the other direction also. That is sections under low stress can be kept thin, so thin in many cases that other matters such as part rigidity become controlling factors rather than material strength. Woven material such as woven roving can also be introduced for localized reinforcement as required and the twin-tip resin nozzles used to wet out the glass.

Fast gel time and rapid cycling of molds—one of the major problems which plague the custom fabricator is how to get a sufficient number of pieces completed within the alloted time with a minimum number of molds. Mold costs always rear their costly heads eliminating many a small-run part from practical FRP fabrication. Because the resin doesn't mix until just before hitting the mold a gel time can be established which allows just enough time to compact the glass resin mix for that particular mold in use. Thus, with a fast curing resin, it allows rapid mold turnover and hence more pieces per mold in a given time. While dual spray guns are used in laminating with mat or cloth, the necessity of impregnating the cloth or mat doesn't allow maximum utilization of fast gel and cure times.

THE SPRAY-UP PROCESS—DISADVANTAGES

Process limitations—as in all production techniques there are important limitations to this process. Successful application of the process requires not only making maximum use of the advantages but minimizing the disadvantages by all means available. The foremost disadvantage is the difficulty in maintaining uniformity of material thickness. The glass and resin are directed by the operator, and he alone is capable of controlling the volume and location of material. In this sense spray-up is a skilled art rather then a precisely engineered manufacturing process.

More resins needed—the custom fabricator frequently encounters an unsatisfied need for a variety of resins to satisfy all requirements; the volume delivery system which facilitates quantity laminating also reduces the flexibility required in the small custom shop. In the past the number of resins with a viscosity and thixotropic characteristics suitable to spray-up have been principally limited to rigid general purpose types. As the spray-up system becomes more widespread it is expected that the variety of resins available for hand lay-up will be duplicated for spray-up, reducing the added expense of custom resin blending now frequently encountered.

Strength—because of the type of reinforcement used it is not possible to obtain the high physical strength obtainable with cloth and woven roving. Continuous roving instead of chopped roving is some help. The physical characteristics can be compared approximately to those obtainable with chopped strand mat in the hand lay-up process.

Further investigation disclosed the then new technique of spray-up. It overcame the drawbacks of hand lay-up:

1. The glass used was in its most inexpensive form
2. Sprayed resin and simultaneous deposition of glass allowed rapid delivery of a high volume of raw material to the mold
3. The mechanical handling of raw materials reduced labor costs
4. Rapid delivery of material resulted in fast gel and cure times—this allowed higher production and more rapid turnover of molds
5. The material has no definable shape, hence molds readily to the most complicated shapes

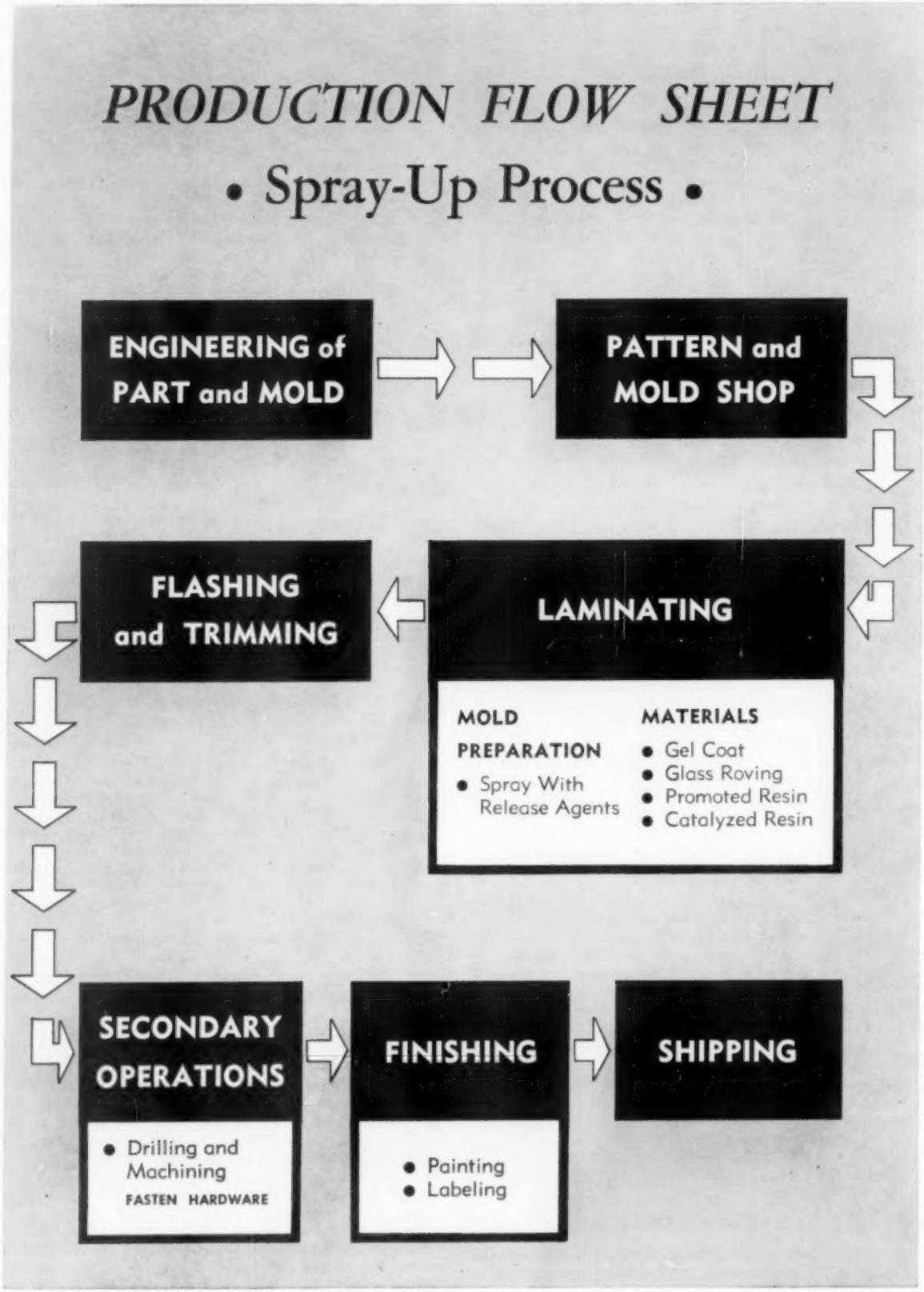
Spray-up, What Is It?

Spray-up is a distinctly different method of fabricating fiberglass reinforced plastics laminates, offering advantages that cannot be as fully realized in other systems. Each of these advantages is derived from the characteristics of the system itself.

Spray-up consists of the simultaneous deposition of at least three elements: (a) promoted resin, (b) catalyzed resin, (c) a reinforcing material usually glass roving.

The promoted and catalyzed resin are delivered from their respective reservoirs in separate hoses to a twin-tipped spray nozzle. The sprays from the nozzles are set to intersect a short distance in front of the tips allowing an external intimate mixing of the promoted and catalyzed resin.

Simultaneously, glass rovings are being fed to a glass breaker where they are usually cut to length ranging from 5/8" to 2" and projected into the resin stream immediately in front of the intersecting resin streams. Here the broken rovings are opened up, tumbled and thoroughly wetted with promoted and catalyzed resin and almost instantly deposited on the surface of the mold. The directing of the


PRODUCTION FLOW SHEET
• Spray-Up Process •
ENGINEERING of PART and MOLD
PATTERN and MOLD SHOP
FLASHING and TRIMMING
LAMINATING
MOLD PREPARATION
• Spray With Release Agents
MATERIALS
• Gel Coat
• Glass Roving
• Promoted Resin
• Catalyzed Resin
SECONDARY OPERATIONS
• Drilling and Machining
FASTEN HARDWARE
FINISHING
• Painting
• Labeling
SHIPPING

glass resin mix is controlled by the operator and it is his skill that determines the uniformity of deposition. This agglomerate is a wet sticky fluffy mass closely resembling a wet polar bear.

The next step is to compact the mass, removing the air to allow the glass and resin to cure to a relatively void-free laminate. Techniques in this step frequently depend on the type and shape of the mold and the ingenuity of the fabricator. Basically the main tools are paint brushes and rollers. These are daubed or rolled until the fluff has been compacted. It is usually necessary to keep the compacting instrument moistened with styrene monomer to avoid picking up glass fibers. These steps are repeated as often as it is necessary to build the laminate to the proper thickness. Glass to resin ratios can be varied by changing either the volume of resin or the speed of glass delivery. In general the most common ratio is about 30% glass and 70% resin. This compares approximately to the glass-resin ratios obtained with glass mat and resin in conventional hand lay-up. It has been reported that slightly higher strengths are obtainable over mat due to superior wetting of the fiber.

Required—Team Concept

The character of the machinery involved soon leads a fabricator to an obvious conclusion. Maximum and efficient utilization of the equipment requires more than just an operator or even an operator and a helper. The spray-up equipment is capable of delivering up to 3 pounds of material per minute, far more than can be easily handled by one man or handled on one mold.

The spray-up operator requires a number of molds ahead of him so that he can spray constantly, this means a number of roller or compactor men must be employed to keep up with the spray unit. This then requires men to prepare the molds, to apply the release, to properly position the molds, etc., another group then is required to flash and remove the pieces from the mold and return the mold to the start of the cycle. Assuming an unlimited supply of resin from a central supply, the only other step is for someone to occasionally add a new supply of glass roving.

The proper number of men per step can best be determined by the type of mold, experience of the employees and most important the experience of the fabricator who is in the best position to evaluate all of the requirements of each operation. Assuming the machinery is mechanically sound and each step efficiently organized, increased production must next come by a duplication of men and equipment.

Quality Control

Quality control is one of the most pressing and most difficult-to-solve problems facing the spray-up process at this time.

It is easy to establish a glass to resin ratio and maintain it from one piece to another if these tolerances are broad enough to include variations of a few percent. This is particularly true if the unit is of at least moderate size. This of course cannot compare with the strict ratios which can be held with prepregs or filament winding but spray-up is better adapted to less critical items such as machine guards where this is adequate. These ratios can be reproduced simply by ensuring that the resin viscosity remains constant and that all pressure guages are set at readings known to deliver proper volumes of material.

Controlling the rate of cure is a problem which almost all laminators, hand lay-up, and spray-up are constantly plagued with. Assuming that the amount of promoter and catalyst are accurately controlled. The three main factors affecting time to gelation and cure, all of which vary from one laminate to another are (1) thickness of laminate, (2) resin rich areas, and (3) atmospheric temperature. Problems (1) and (2) are associated with proper design and workmanship and are handled by job know-how. Problem (3) is usually beyond the control of the laminator unless he is fortunate enough to work in an atmosphere which can be completely controlled the entire year. If the laminator works in an old type building as many do, he finds that the only time he has a relatively stable temperature is in the middle of the summer and winter season. The summer because of the generally uniform outside temperature and the winter because the plant's temperature is stabilized by a central heating system. In the Spring and Fall or any changing season he must adjust his catalyst promoter ratios by his estimate of the prevailing temperature over the next 24 or 48 hours. This introduces an uncertainty which is difficult to remedy.

Degree of cure has considerable affect on the physical character of all fiberglass laminates. If, as is generally the case in spray-up, the laminator must rely on a room temperature curing system he must make allowances for physical characteristics which may take a prolonged period to develop.

The quality control problem which is perhaps most unique to spray-up is that of ensuring the uniform depositing of material by the operator. The operator directs the flow of material and hence the buildup. Various methods have been tried, one of which is a timer which indicates the length of time and hence quantity of material which is deposited. These are merely aids. The operator's skill ultimately determines the uniformity of the laminate. Only a skilled operator can produce consistently uniform pieces. Parks & Woolson have been consistently able to produce laminates weighing approximately 175 pounds each with a variation of only three pounds or 1.7%, which we feel is a good performance for this process.

Quality control in spray-up depends primarily on skill and judgment. It would appear now that highly exact and impersonal methods of quality control would not appear adaptable or perhaps even suitable for the process in its present form.

Process Improvement

The continual improvement of reinforcements and resins has been of considerable assistance. A wider variety of resin suitable for spray-up would be helpful with perhaps more investigation into the potentials of synthetic fibers for special applications where glass has not proven as successful as desired.

Existing equipment needs to be improved to make it more foolproof and reduce the amount of expensive "house cleaning" which is required to insure reliable operation. These all take time and money, all of which will come about when the process is better understood and accepted on its own merits.

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Safety Precautions

Follow strict program of personal hygiene.

- *Use gloves and barrier creams.*
- *Use face masks while grinding and sanding.*
- *Use heavy gloves while handling sharp edge laminates.*

For a comprehensive article on safety in handling liquid thermosetting resins, the reader is referred to the article Caution: Handle With Care, published in the March 1961 issue of the SPE JOURNAL, pp. 225-230.

Decorating of Plastics

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Looking for a decorating process for your plastic products? This article describes several, including spray coating, spray and wipe, silk screening, and vacuum metallizing. Applications, limitations and advantages of each of these methods are discussed. The decorating medium chosen for any specific application is a function of the geometry, polymer type and prime coat of the surface and of the composition of the coating system

The variety of methods used to decorate plastics have inherent characteristics which dictate their use. Part design, available equipment, cost factors, durability of the decorated part and coating properties are additional considerations which must be made to insure success of decorating. The bulk of decorating of injection molded thermoplastics is done with air dry lacquers, whose intrinsic properties can directly effect the sequence of operation of multi-method decorating.

Lacquers, particularly desirable for use upon thermoplastic surfaces because their films harden without baking, are very fast drying resinous materials which dry solely through solvent evaporation. Since they undergo no chemical change, lacquers may be redissolved quite readily in their own solvents. Problems with subsequent decorating can arise because of this trait of lacquer films. A basic understanding of the makeup of lacquers can be of help to those who wish to make slight coating adjustments to overcome a shop problem, or to those who wish to design a part with ease of decoration in mind.

The resin system, with plasticizers and pigments, is that portion of a paint which remains upon the part after the solvent has evaporated. A specific paint may be composed of more than one resin. The base resin is generally one that affords the unique or primary film properties and the remaining resins are added to obtain additional physical properties such as grease and humidity resistance, or adhesion of vacuum deposited aluminum. At least one resin must be a film former, and often lower molecular weight, non-film forming resins are used as additives. Lacquer films are thermoplastic in nature and can be made from numerous resins including nitrocellulose, cellulose esters, cellulose ethers, polyacrylates and polyvinyls, with hundreds of other film modifiers possible for special properties.

The solvent system is designed specifically for the method of application of the paint, but all solvent systems have several characteristics in common. The blend must be a solvent for the resins and in particular the highest boiling (slowest drying) solvent must not only be a solvent for the resins to insure the dried paint film is continuous, but also must not attack the plastic. Diluents, not solvents for the resins, may be added to the paint. They must be no slower drying than the high boiler and should be added carefully lest they precipitate the resins from solution if too much is used.

Normally a lacquer can be applied over itself with no visible harm during normal spray, screen or roller coating operations, although objectionable visual damage can occur through the use of a combination of methods where the solvent of the second coat detrimentally effects a previously applied coat. To preclude these problems a natural sequence of operations is generally preferred. The

METHODS CHART

First Coat ▶ / Second Coat ▼	SPRAY	SPRAY AND WIPE	SILK SCREEN	ROLL COAT	HOT STAMP	VACUUM METAL-LIZING	FLOW COAT	DIP
SPRAY	Yes	Caution	Yes	Yes	Yes	Caution	Not applicable	Caution
SPRAY AND WIPE	Yes (2nd surface)	Not recommended	Not applicable	Not applicable	Not applicable	Yes (2nd surface)	Not applicable	Not applicable
SILK SCREEN	Yes	Caution	Yes	Yes	Yes	Caution	Not applicable	Not applicable
ROLL COAT	Yes	Caution	Yes	Yes	Yes	Caution	Not applicable	Not applicable
HOT STAMP	Caution	Not recommended	Caution	Caution	Yes	Caution	Not applicable	Not applicable
VACUUM METAL-LIZING	Caution	Caution	Caution	Caution	Yes	Not applicable	Not applicable	Not recommended
FLOW COAT	Yes	Caution	Yes	Yes	Yes	Caution	Not applicable	Caution
DIP	Yes	Caution	Yes	Yes	Yes	Caution	Not applicable	Caution

This chart is based upon the use of Air Dry Lacauers. Horizontal columns indicate method of application of first coat, vertical columns indicate second method of decoration.
It is assumed subsequent coatings will be in contact with first coat.

It is assumed subsequent operations are to be applied to completed vacuum metallizing system composed of base coat, aluminum and top or back up coats. Where metallizing is the 2nd operation, caution is indicated since first coat must be specifically designed as a base coat.

Methods Chart, shown, has been prepared to assist in avoiding problems due to sequence of operation.

The *Methods Chart* illustrates the more common methods of decorating thermoplastics and is based upon decorating thermoplastics with air dry lacquers. The horizontal columns indicate that method by which a coating is first applied, and the vertical columns indicate the second method of decoration. It is assumed the second coating will be in contact with the first. The chart indicates the trouble free application of a silk screen coating onto a spray coating, whereas precautions may be required to apply a spray coating over hot stamped tape. We shall examine some of the more common decorating methods to point out possible trouble spots and also to indicate some steps to be taken to avoid them.

Spray Coatings

Spray coating is widely used to decorate all types and sizes of plastic parts. The method is particularly adapted for painting large areas, uneven surfaces, and for the application of multiple colors with the use of spray masks. Spray coating is quite economical and adapts itself to a wide variety of special paints oftentimes designed for ease of production as well as for the end physical properties displayed by the dried paint film.

The solvent system of spray paints is composed of low, intermediate and high boilers. The system is balanced to afford low viscosity for spraying and a higher viscosity when the paint reaches the plastic. This is done by selecting a low boiling component which will be blown away during spraying, thus increasing paint solids and viscosity. The intermediate and high boilers are selected to allow the freshly applied paint film enough viscosity to flow out properly, yet hold to corners, and to prevent diametrically opposite problems of orange peel and cratering. The *table* illustrates paint solvents classified by boiling points.

Normally paints are formulated not to attack plastic surfaces; however, a paint may etch a polystyrene molding if the styrene has been molded with a high amount of internal stress, perhaps especially in the sprue area. An alcohol type solvent, or a diluent recommended by the paint manufacturer, can be added to the paint to 'cool down' the activity. In severe cases the amount of diluent required to prevent etch may give cause to unforeseen problems of color variation or humidity blush.

This color variation can be caused by a lean solvent system allowing pigment flocculation—the phenomena of one or more pigments breaking their dispersion and clumping together. If a yellow pigment begins to flocculate the resulting sprayed color will be yellow shy and off-color. The

Classification of Paint Solvents by Boiling Point

Low Boiling	Intermediate Boiling	High Boiling	Extra High Boiling
Methanol	Isopropyl Alcohol	Amyl Acetate	Cellosolve acetate
Ethyl Acetate	Sec-butyl Acetate	Butyl Acetate	Butyl Cellosolve
Isopropyl Acetate	Methyl Cellosolve	Butanol	Butyl lactate
Acetone	Methyl isobutyl ketone	Diisobutyl-ketone	Methyl Carbitol
Methyl-ethyl-ketone	Toluene	Xylene	SC-150
Hexane	VM & P Naptha	SC-100	
Heptane		Methyl Cellosolve acetate	

flocculation can be avoided by adding a better solvent or broken through mechanical work such as mixing. In borderline cases, the mechanical work imparted by spraying can disperse flocculated particles.

The diluent, to be effective in preventing etching of the plastic, must be comparable in evaporation rate to the intermediate or high boiling 'problem' solvent. Care must be taken to prevent the concentration of diluent becoming too great or solvent blush may result. If the diluent-solvent mixture is too lean the paint resin will precipitate from solution, causing blush manifestations of loss of gloss and adhesion. Humidity blush, resulting from water condensing from the atmosphere as solvents evaporate, is also possible if the water-diluent-solvent mixture is too lean to keep the resin in solution until dried.

There is considerable freedom of selection in the solvent system of spray paints as compared to screen, dip or roller coatings, hence for all but extreme cases, special 'problem solving' paints are available.

Spray coatings are one of the easiest applied coatings and usually are trouble-free, although perhaps the most difficult colors to spray are metallics. Abrupt color change is detected if the paint etches the plastic because the metallic particles will align themselves differently over the etched area as compared to non-etched surfaces. In addition, care should be exercised to prevent flooding the paint which also radically effects color of metallic coatings.

Specific properties can often be 'built-in' a coating to solve unique production problems. An unusual coating demonstrates economical advantages to vacuum formers of tripolymer (ABS) plastics for interior automotive applications. Many of these parts require bright metallic colors which will meet high quality physical requirements of crock resistance, flexibility, color uniformity, light stability and humidity resistance.

To achieve many exotic automotive colors it is common practice to spray a color coat and a protective top coat of lacquer onto the previously formed part. To facilitate production spraying and to ease storage problems, extruded or calendered sheets are painted before forming. Painted sheets are then stacked. Inventory problems are greatly reduced because of the comparatively small floor space required for storing flat sheets as opposed to bulky formed parts. When special colors are required, the painted sheet stock is removed from storage and moved to the forming area.

Special coatings allow this economy and versatility because they can be applied in thick films which with a 2 to 3 minute force drying at 140°F dry quickly after spraying and are hard and mar resistant enough to allow for stacking, with no blocking problems. During the preheating before forming at 400°F., the coating undergoes further cure and reaches its ultimate physical properties. Thus, one coat does the job of two coats since no top coat is required, which drastically reduces production costs.

Spray and Wipe

Spray and wipe is the method of decorating indented portions of a plastic molding when it is desired to eliminate the use of close-tolerance, electro-formed spray masks. The coating is sprayed into the indented areas, sometimes confined to the general surrounding area by a rough block mask, and is then wiped away from the surrounding surfaces leaving paint only in the depressions. Basically, two types of spray and wipe coatings are used; wet wipes and dry wipes.

Wet wipes are normal air dry spray paints which are removed from the plastic with a solvent intrinsically blended to remove the paint without damaging the plastic. Wet wipe coatings are used for parts requiring excellent durability such as on first surface applications where adhesion and hardness are important. They are also often used for applying metallic colors. The removal of the coating is dependent upon dissolving the paint, therefore, caution must be exercised should a spray and wipe be used as a second finishing operation over a previously applied coating. It is essential the spray and wipe coating does not, in any manner, attack the first coat and of course it is mandatory the solvent used for removal of the spray and wipe not effect the previously applied coating. Therefore, the base coat and the wiping paint must be of dissimilar resin construction.

The development of dry wipe coatings is an excellent illustration of coatings developed primarily for their value to the plastic decorator rather than for the benefit of the end user.

Usually dry wipe coatings are sprayed upon the part in the same manner as wet wipe materials, however, after application they dry to a fine powder which can be removed with a dry cloth. Within an hour or so after application dry wipe coatings weld into a solid mass, closely resembling conventional lacquers, and have a fair degree of adhesion to the plastic or previously applied coating. Generally, dry wipes are fairly safe to use over previously applied spray, screen or roller coating materials. Caution should be exercised when applying dry wipes over hot stamped or vacuum metallized coatings.

Because of their durability, dry wipes should be used only on properly designed first surface applications. They are not as hard nor do they adhere as well as conventional lacquers, hence the preferred design for first surface depressions has a ratio of depth to width of 1½ to 1. Thus, there is little possibility of the dry wipe being smudged out of the depression. There are not unusual design limitations for second surface work since the plastic protects the letter fill.

When used properly dry wipes are excellent materials since they can increase production rates by as much as 1,000%. Generally, they are limited to black, white and pastel colors, although some of the daylight fluorescent colors are also available. They are not available in metallics and in some of the deeper masstone colors such as reds, blues and greens.

It is not considered good practice to use wet or dry wipes in an operation subsequent to hot stamping unless the spray and wipe material can be kept completely isolated from the hot stamp tape. For second surface applications it is desirable to use spray and wipe as the first operation and then follow with succeeding decorating methods, thus eliminating the possibility of the solvent detrimentally effecting later work. Care should be taken in all cases when applying spray and wipe over metallic paints.

Silk Screening

Silk screening is used extensively for printing both flat and curved surfaces of molded plastic items. It is particularly adaptable for multi-color decorating, by successive screening impressions, using a series of different screens. It is more economical than spraying to obtain elaborate designs since fine detail screens are cheaper than elaborate precision spray masks and further there is no need for engraving the mold for paint breaks. Many different designs can be accomplished economically by molding 'blanks' or flat panels and merely changing the screen design for model changes. Of course, screened designs do not have the three dimensional depth effect obtainable with second surface spray decorating.

Silk screen inks can be made in most any color including metallics; however, for very fine detail work when it is necessary to use fine mesh screens, brilliant metallic colors can prove troublesome because the coarser particles, necessary for brilliant colors, will not readily pass through the screen mesh. The result can be loss of detail and a high proportion of rejects. The problem can be avoided by compromising the color and reducing the metallic particle size.

Care should be exercised if spray coatings are to be used subsequent to screened metallic colors on the second surface. It is possible for slight color changes to occur resulting from the spray solvents effecting the leafing of the screened color. This problem can often be avoided by allowing the screened film to completely dry before spraying, by spraying the paint 'dry' or by a solvent change in the spray coating.

Roller Coatings Can Eliminate Close-Tolerance Spray Masks

Often a molded part has debossed copy or a raised area which must be coated. The two most commonly accepted methods for accomplishing this are hot stamping or roller coating. The choice of which to use is a matter of economics. Small parts to be run in large quantities are more economically hot stamped. Large areas, such as the flange around a TV mask are more often roller coated because if hot stamped a large amount of tape would be wasted. For best results, the raised areas should have smooth, flat surfaces, and all surfaces to be roller coated in one operation should be in one plane or in a smooth arc. All edges and corners should be sharp for good detail.

Lacquers can be formulated to be applied by roller coating. Generally, such lacquers are similar to screening coatings but are applied at lower viscosity.

The use of roller coating strip coats is becoming a common practice to eliminate costly electro-formed spray masks.

Flat parts with second surface indented areas can be roller coated with a strip coat which masks all but the depressions. Subsequent spray decorating or vacuum metallizing can be accomplished without electro-formed spray masks or numerous masks used in the vacuum chamber. With some ingenuity, complicated decorating can be done without masks, when this principle is used with dry wipe coatings or coatings which can be applied directly to both the base plastic and the vacuum deposited aluminum.

Precaution When Painting Over Hot Stamping

The industry has seen a large increase in the use of hot stamping with both pigmented and bright (vacuum metallized) foils. It is sometimes desired to apply a top coat of clear mar-resistant paint over the hot stamped tape to afford extra durability; in other cases, for second surface applications, the hot stamp operation may be the logical first step with spray or screen operations to follow. Production problems may result from paint solvents etching or crazing the foil. To locate the particular paint whose solvents will not attack the foil and yet are fast drying, and with a resin system which will pass appliance or automotive specifications is sometimes exceedingly difficult. The problem is compounded because of the vast array of foils available. Therefore, special paints must be used oftentimes and care should be taken to insure a specific coating will continue to perform if a change of hot stamp tape is made. Some tapes are virtually impossible to coat without detrimental effects which may come and go without apparent reason due to subtle changes in the foil, paint or both. As a precaution it may be desirable to mold the part with paint breaks so that spray masks can be used to insulate the hot stamped foil. These breaks, .020 to .030 inches, indented or protruding can also serve to enhance the visual appeal of the molded part.

Generally there is no problem hot stamping over paint. Most plastic paints are thermoplastic themselves and thus good adhesion of the foil is readily attained.

Vacuum Metallizing Coatings

Vacuum metallizing coatings can be applied by any of the common methods of decorating but, assuming the basic prerequisites of metallizing such as almost perfect flow-out, no trace of etch, and adhesion of the plated aluminum, metallizing paints are distinctly different from those used for normal decorating.

It is considered mandatory that all coatings used immediately beneath or above the aluminum be specifically designed for vacuum metallizing.

Extreme caution must be exercised in all cases of subsequent decorating over a complete vacuum metallized system (composed of a base coat, aluminum and the top coat or back up coat). Second surface work is especially critical since any solvent attack upon the metallized system will immediately become apparent because the brilliant vacuum plate tends to highlight faults. Spray and wipe is not considered a good practice over vacuum metallized coatings and caution is required when spraying, screening or roller coating over these surfaces. The range of vacuum metallizing coatings is too broad for present discussion, but special coatings will allow for complete freedom of production methods.

Flow Coating and Dipping

Flow coating and dipping are methods frequently used for applying clear vacuum metallizing base coat and top coats. They are sometimes used for normal decorating of toys and novelties which require only one color; however, because of color limitations of parts prepared in this manner their uses are restricted.

Paints used in either method must be carefully formulated so that solvent etching or crazing of the plastic is precluded or is not visually noticeable. Because the entire plastic part may be coated, solvent which may cause swelling or softening of the plastic must be avoided. Should there be occasion to dip over a previously applied paint film, the two paints should be dissimilar so the dip color is not contaminated with color dissolving from the part.

Instrumental Specification of Color

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A method for supplementing visual color matching by use of a reflectance meter

Color matching techniques have historically relied on visual acuity and human judgment with the ability to see color uniformity reflecting the observer's physical, chemical, physiological, and psychological make-up. The reliance by industry on instrumental control has increased steadily in recent years until it has become generally apparent that, where volume production prevails, it pays to supplement the trained eye with the special techniques and tools of color measurement.

In the manufacture of multiple-part plastic products there is a problem of visual color acceptance or rejection of plastic sub-assemblies which are inspected at varying times or by different inspectors who use visually selected and color-matched standards. When these sub-assemblies meet in the production cycle for assembly into the final product, a noticeable color difference may be perceived. It is readily understandable that if the color standards themselves at two or more inspection stations were non-color conforming, the production assemblies could not help but be off-matches.

Prior to the introduction of a new plastic telephone, i.e. the Petite, it was determined that an instrumental color control program should be instituted to provide the needed control over the final product.

The first problem in the new program was to select an instrument that would meet the technical requirements, be simple to operate, and still be economically justifiable. The unit selected was a reflectometer manufactured by Bausch & Lomb Incorporated. This instrument is designed to measure total reflectance less part of the specular component and utilizes Illuminant C, a standard representation of average daylight. A schematic diagram below illustrates this reflectance mechanism shown in the photograph, *Figure 1*.

The color analyzer is intended for the measurement of the diffuse reflectance of opaque specimens relative to a calibrated working standard. The basic photometric equipment of the color analyzer is the Spectronic 20 Colorimeter-Spectrophotometer. The reflectance portion of the system consists of two units, the power supply and the measuring sphere. White light after being dispersed by the diffraction grating is brought through the bottom of the sphere and allowed to strike either the sample or the standard. The reflected light in the integrating sphere is then measured by means of a multiplier phototube and is directly indicated on the meter.

Another reason that this type of unit was selected to fulfill the requirements of the investigation involves the graphic specification of a color without the need of comparing the test sample to a similarly colored test standard. Although colored porcelain enamel panels are relatively color stable, it was felt that enough of a change could occur in the standard over a period of time to provide a color shift of noticeable difference. It was therefore beneficial to utilize a numerical specification that would not alter with time. It was furthermore mandatory that the data obtained limit

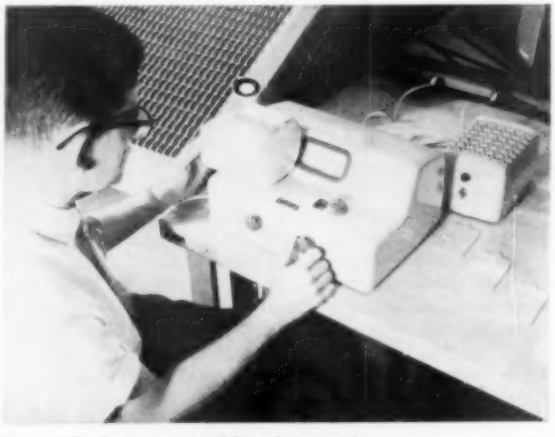


Figure 1. Spectronic 20 color analyzer

Table 1. Reflectance Readings and Computed Coordinates of Turquoise Samples

		TRICHROMATIC COEFFICIENTS Reflectance Readings										Computed Coordinates				
	Chip No.	415	445	475	505	535	565	595	625	655	685	X	Y = Rd	Z	—a	—b
1	T-5144	64.0	68.1	71.5	79.0	69.5	50.0	39.6	36.9	39.7	38.5	47.62	56.49	80.11	18.36	10.65
2	T-5144	65.7	68.4	71.0	78.3	69.8	51.0	40.0	37.2	39.5	38.4	48.03	56.84	80.23	18.33	10.38
3	T-5144	64.4	47.9	71.6	78.6	69.1	50.0	40.0	37.0	39.6	38.7	47.70	56.42	80.03	18.20	10.66
4	T-5144	66.2	68.8	71.2	78.5	70.0	50.8	40.3	37.9	39.6	38.1	48.29	56.99	80.61	18.03	10.54
5	T-5144	66.4	68.9	71.8	78.5	70.1	51.0	40.1	37.2	39.9	38.2	48.21	57.01	80.81	18.26	10.75
6	T-5144	65.8	68.0	71.2	77.8	60.8	50.9	40.1	37.1	39.8	38.0	48.00	56.77	80.03	18.26	10.30
7	15685	64.5	67.9	71.3	77.4	69.0	50.1	40.0	37.1	39.4	37.9	47.21	56.26	79.85	17.85	10.69
8	T-5144	65.1	68.5	71.0	79.0	70.3	51.0	40.1	36.9	39.3	37.6	48.03	57.05	80.39	18.80	10.21
9	T-5144	65.1	68.7	72.1	79.0	69.9	50.2	39.3	37.0	39.1	38.4	47.71	56.62	80.81	18.63	11.07
10	T-5144	65.1	68.9	72.9	80.0	69.5	40.3	39.8	37.0	39.6	38.5	47.93	56.81	81.28	18.49	11.25
11	T-5144	65.0	67.5	71.0	78.7	70.3	51.4	40.2	37.2	39.6	38.0	48.08	57.16	79.64	18.91	9.58
12	T-5144	65.9	68.8	71.2	79.0	70.0	50.9	40.2	37.3	39.8	38.0	48.18	57.01	80.62	18.36	10.51
13	T-5144	65.3	68.8	71.8	79.0	70.0	51.1	40.1	37.3	39.9	38.0	48.21	57.08	80.78	18.42	10.57
14	T-5144	66.0	69.0	72.3	79.2	71.0	51.1	40.3	37.5	39.7	38.3	48.42	57.43	81.17	18.67	10.52
15	T-5144	65.3	68.5	71.8	79.0	70.3	51.5	40.1	37.3	39.5	38.0	48.25	57.26	80.60	18.71	10.24
16	T-5144	66.1	69.0	72.0	79.5	71.2	52.0	40.9	38.0	39.9	38.5	48.87	57.92	81.10	18.65	9.95
	T-5144-1	65.8	68.8	72.1	78.2	69.9	50.7	40.0	37.6	40.3	39.0	48.21	56.87	80.80	17.97	10.87

the boundaries of the color match to a just-noticeable difference. The latter requirement eliminated the specifying of colors by dominant wavelength and purity due to the difficulty of determining the deviation boundaries.

Test Procedure

Sample chips of each of six pastel colors were submitted by Marbon Chemical Company, manufacturers of Cycolac ABS Plastic, for examination. The colors and number of samples including the Master Standard for each color were as follows: Turquoise, 17; White, 12; Pink, 12, Biege, 12; Blue, 12; and Blue-Biege, 16.

In order to correlate the visual and instrumental phases of the program, all samples were initially inspected by the plant Quality Assurance group under a Mac Beth Daylighting Corporation's Examolite TC-440 controlled north daylight as shown in the photograph, *Figure 2*.

Each sample was individually compared to its Master Standard. It was determined by the group that all samples were visually acceptable to their respective Master Standards and could be used as sub-masters for inspection purposes.

The samples and Master Standards were then analyzed by the reflectometer through the following procedure:

1. The reflectometer was first standardized against a magnesium carbonate block to a 100% reflectance value and was then standardized against a white porcelain working standard for convenience of operation.
2. The colored plastic samples (3-½" x 2-½" x ⅛") were next read through ten different wave length values of the visible range from 415 mu to 685 mu. *Table 1* indicates the reflectance readings and computed coordinates of the Turquoise samples.
3. The reflectance values were mathematically converted to the chromaticity coordinates and to the Hunter units.
4. Permissible Deviation graphs were prepared from the computations.

The tristimulus values were initially obtained by the following method:

The reflectance readings of the particular color were observed and recorded at ten different wavelength settings of the visible range. Each wavelength reading was adjusted by a multiplying factor (Bausch & Lomb's Illuminant C Trichromatic Computing coefficient) to give tristimulus values. These values were obtained for X, Y, and Z and then converted to the Hunter Units by using the formulae:

$$R = 100Y$$
$$a_R = 175\ (1.02X - Y)$$
$$b_R = 70\ (Y - 0.847Z)$$
$$f_y = 0.50\ (21 + 20Y)/(1 + 20Y)$$

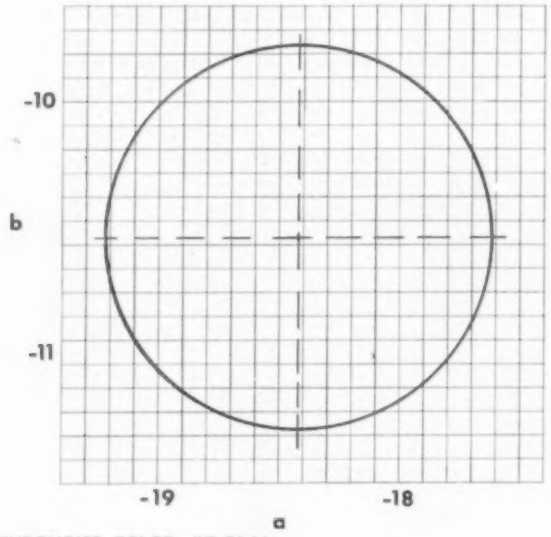
It is apparent that the above data do not necessitate a mastery of higher mathematics (as do the theories behind their use) but do require considerable and detailed computations which may lead to arithmetic errors due to length of the computations involved. To eliminate such a source of

Figure 2. MacBeth Daylight Booth

error and to shorten the time of obtaining the mathematical results, the reflectance data were directly programmed on an IBM 650 Computer to give not only the chromaticity coordinates but also the desired Hunter unit values.

The a_R and b_R values for each chip were plotted as x and y ordinates respectively and the circular area enclosing the coordinates of all the samples of the individual color marked as the limit of deviation, the center of this circle being taken as the geometric mean of the a_R and b_R values and the radius of the circle used as the deviation permissible in Hunter units. The average of the R readings was taken as a mean reflectance value with the high and low values of R used as the limiting range.

As a check on the System, readings were taken on the same samples on a Hardy Recording Spectrophotometer and on the Spectronic Color analyzer. Although the reflectance curve checked closely to the curve produced by the Hardy Recording Spectrophotometer, the values computed in Hunter units differed from the values obtained by Marbon Chemical Company on the master samples when read on a Hunter color difference meter. This was interpreted as the inability of different instruments to locate exactly the same color spacing in the color solid with identical coordinates. If two instruments are of the same order of accuracy, the difference between the readings of the two can be corrected by a factor added to each coordinate, the size of the factor depending on the point in the color solid containing the discriminated color. There is little doubt but that the two instruments involved in the study will need to be re-coordinated from time to time in order to correct for equipment drift.



TURQUOISE COLOR #T-5144

Spectronic 20 Color Conversion Chart (R_d Range 56.42-57.92) Permissible Deviation 0.8 Hunter Units R_d 56.94, a −18.42, b −10.57

Shown is a typical permissible color deviation chart of the Turquoise color as computed and converted from reflectance data as described above. It is readily apparent from the chart that the radius of the circle is the allowable difference from the color mean that can be tolerated as a color match. Color coordinates falling outside of this circle are considered to be off-matches and are rejectable as such.

Interpretation of Results

Various conclusions are drawn from the results of the investigation. Heading the list is the most important one that the instrumentation system would be too slow to replace visual inspection of production parts but should be vigorously used to control and supplement visual inspection by trained observers and may also be effectively utilized for settling differences of opinion of color matches. In other words the system, as studied, is feasible and practical and has, since the writing of this article, been incorporated as a company practice.

Secondly, it is concluded that further and continuing studies should be initiated in the field of color interpretation that would aid in the better understanding of color problems as they arise and, consequently, serve in the more efficient solving or control of these problems.

Lastly, color problems are obviously not restricted to plastics but are a component part of paints, leather, textiles, inks, etc. and the controlled color system should eventually be extended to all products that require critical color matching of component parts.

Acknowledgments

Special thanks are due to Dr. N. Kreidl, Dr. J. Rood and Mr. W. Kirchgessner, of Bausch & Lomb Incorporated, for their help and guidance in various phases of the investigation, and to the Marbon Chemical Company for their cooperation in supplying data and test samples.

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2. Hardy, A. C., "Handbook of Colorimetry", The Technology Press, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1959.
3. Wright, W. D., "The Measurement of Colour", The MacMillan Company, 1958.

Errata

December 1960, SPE Journal, Polyesters as Corrosion Resistant Coatings, page 1317, we inadvertently failed to note that "Bentone" is a registered trademark of the National Lead Company.

March 1961, SPE Journal, Chemically Cross-Linked Polymers, page 266, another trademark slip. We indicated that Agerite Resin D and Thermax are trademarks registered by the R. T. Vanderbilt Company. Actually they are the respective trademarks of the B. F. Goodrich and the Thermatomic Carbon Company for polymerized trimethyl dihydroquinoline and MT carbon black.

November 1960, SPE Journal, Stress Relaxation and Creep Measurements of Some Thermoplastic Materials, pages 1235-40, the following errors and omissions were brought to our attention:

a) All temperatures should be in Degrees Kelvin for calculation purposes.

b) Appendix 1 page 1240—insert β (Greek letter beta) before e in equation 3.

c) Appendix 1 page 1240—the S in the right hand side exponents in both equations 6 and 7a should be changed to δ (small Greek delta).

Two Flexible Epoxy Resins

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Coatings Technical Service, The Dow Chemical Company

The bisphenol based epoxies are now offered in sufficient variety to satisfy most industry needs for rigid resins. Other types, epoxy novolac and those derived by olefin oxidation serve other more special applications. But where the inherent brittleness of such systems is a problem, the field of flexible modifiers has not been thoroughly explored.

The advent of two new reactive epoxy modifiers promises new latitude in formulating. Both are diglycidyl ethers of aliphatic glycols, and both contribute toughness or outright flexibility to any epoxy system in which they appear.

Since neither is a pure compound, each has been assigned a code number. The resin of higher molecular weight and higher viscosity is Experimental Resin X-2673.2, while the resin of lower molecular weight and viscosity is X-2673.6, *Table 1*. These are referred to as Point-2 and Point-6.

Each resin is commonly used in a blend, usually with ordinary liquid epoxy resin such as D.E.R. 331. These new epoxy additives contribute more than just flexibility. They have excellent color and very low viscosity, indicating that they may be efficient reactive diluents where the flexibility contribution is of little or no concern.

Flexibility in Thermoset Resins

The mechanical properties of any amorphous thermoplastic resin at any temperature are determined by the nature of its linear polymerization, that is, the molecular weight and molecular weight distribution. In thermosetting systems, the frequency of crosslinking is an added factor. Epoxy resins are no exception to these rules.

Normally rigid, crosslinked epoxy systems may be modified for increased toughness and flexibility in several ways: The crosslink density may be reduced by the use of an epoxy resin of higher initial molecular weight. Since only the end sites are reactive, there will be less crosslinking per unit volume. Alternatively, an inert plasticizer may be added to spoil chain packing and to lubricate chain wriggling into new configurations as flexing stress is applied.

Two new flexible additives represent a third way. An inherently flexible, aliphatic glycol diglycidyl ether is added as a modifier with the common rigid epoxy. Random incorporation of these flexible molecules into the network softens it internally.

Of the three techniques, modification of the epoxy resin by addition of a flexible resin seems very desirable, especially where the flexible component also contributes low viscosity and optical clarity.

The hardener can also affect flexibility. The use of the flexible epoxy additive still leaves the option of added modification by selected curing agent. Obviously, the blended system must be compatible with the chosen hardener, and be sensitive to its curing action. These polyglycol diglycidyl ethers qualify on both counts for a number of simple curing agents. The higher molecular weight resinous hardeners are other interesting possibilities.

Modification of epoxy resins by addition of a flexible, aliphatic glycol diglycidyl ether

Testing Resins Point-2 and Point-6

The effect of a flexible resin component on a cured, normally rigid epoxy system depends on its concentration, and on the hardener used in curing. Each of these flexible resins has been tested in blends with a standard liquid epoxy D.E.R. 331, using diethylenetriamine, methylene dianiline and methyl Nadic® anhydride as hardeners.

Each blend was mixed with hardener at 140°F, then cast in half-inch square bar molds. Systems cured with a chemical equivalent of diethylenetriamine or methylene dianiline were gelled at room temperature. The DETA systems were postcured two hours at 100°C, and those gelled with methylene dianiline were postcured four hours at 200°C. Samples containing the 0.9 chemical equivalent of methyl Nadic® anhydride were cured four hours at 80°C and 15 hours at 150°C.

Results of some flexure, compression and heat distortion studies are presented graphically. The mechanical strength values were obtained by ASTM methods, using a Baldwin

Table 1. Physical Constants

	X-2673.2	X-2673.6
Epoxide Equivalent Weight	330	195
Viscosity, 25°C, Centistokes	57	44
Specific Gravity, 25/25°C	1.0583	1.1518
Refractive Index a = 20°C, b = 25°C	1.4568	1.4668
Color, APHA	5	20
Flash Point, °C	210	199

® Reg. Trademark, The National Aniline Division

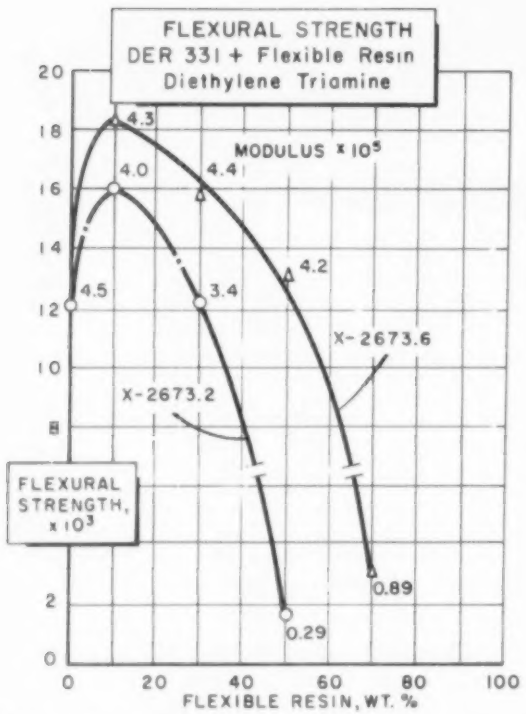


Figure 1. Only 10% of flexible resin greatly improves flexural strength

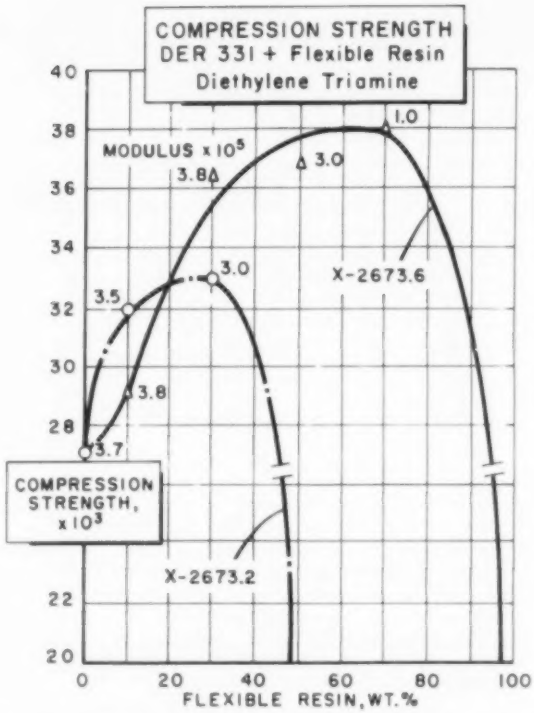


Figure 2. Graphs show improved resistance to fracture at the 10% flexible resin level

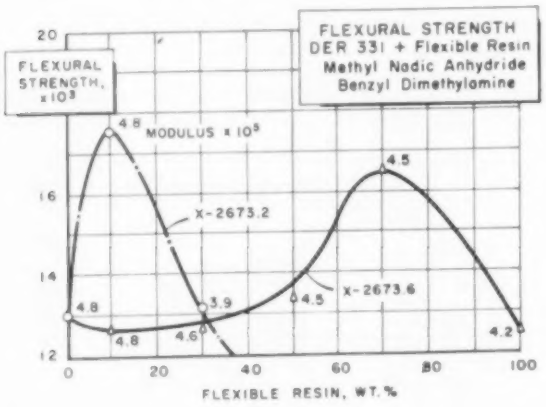
Tate-Emery instrument. Heat distortion temperatures were measured by the method ASTM-D-648-56.

Discussion

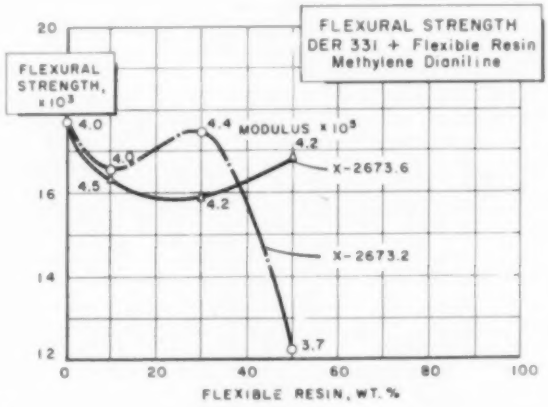
Figure 1 illustrates the effect of flexible epoxy additives on a normally rigid system, cured with diethylenetriamine. A small quantity, only 10% of either flexible resin greatly improves flexural strength, apparently reducing the sensitivity to mechanical stresses concentrating at small flaws in the test specimen. Note the interruption in the curves in *Figures 1* and *2*. This denotes a transition from rupture of the relatively rigid specimens, somewhere above the break, to yield without rupture at very low modulus, below the break. Modulus values are recorded on the Figure, adjacent to the specimens they represent.

Now in this region of yield rather than rupture, the Point-2 resin results in about the same decrease in modulus at 50% that the Point-6 does at 70%. The former is the more efficient flexibilizer.

Figure 2 on compression strength shows again the improved resistance to fracture at the 10% flexible resin level, which property we like to call toughness, when compared to the brittleness shown by unmodified epoxy. We conclude that higher compression strength results from deformability and relative insensitivity to stress concentration at flaws. This allows greater distortion of the specimen. A correction



3A



3B

Figure 3. A comparison of flexural strengths of a system cured with methyl Nadic anhydride, and one cured with methylene dianiline.

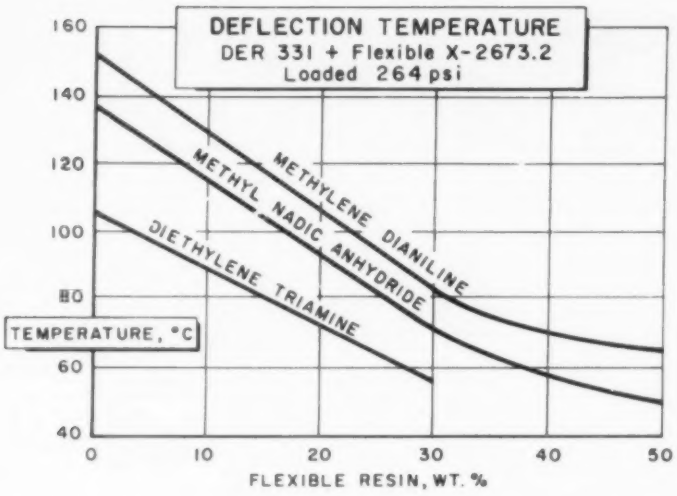


Figure 4. Reduction in heat distortion temperature — one disadvantage of flexibilizing an epoxy system

for this change in shape during compression would probably make these results less dramatic. As it stands, the compression strength at the 30-50% level of resin Point-6 is almost half again as great as our basing point; approximately 37,000 psi. against 26,000 for the rigid resin system without flexible addit.ve.

With aromatic amine and anhydride hardeners the change is less striking. *Figure 3* is a comparison of flexural strengths of a system cured with methyl Nadic anhydride, and one cured with methylene dianiline. Curiously, this aromatic amine seems to show many of the attributes of an anhydride in its effect on mechanical properties, probably because of similar aromatic structures.

In this particular flexural test with anhydride hardeners, the Resin Point-2 at low concentration brought greatly improved strength. Resin Point-6, of the lower molecular weight, caused an initial slight degradation. At the 50-70% level of Point-6 we do see improvement as expected. The strength at 100% Point-6 approximates that of a standard, rigid epoxy resin, and without appreciable drop in modulus. From this we must conclude that Point-6 is not a very efficient flexibilizer in anhydride systems. This may often be an advantage. Large concentrations will reduce the viscosity greatly, with very little effect on many of the physical properties. Systems cured with anhydride hardeners provide the rare case where the polyglycol diglycidyl ethers may be used alone, that is, without added resin based on bisphenol A.

Continuing with the comparison in *Figure 3B*, we see that a system cured with methylene dianiline shows a similar initial degradation in strength, and with Point-2 resin, hardly recovers. The Point-6 system is trending upward, but we lack the necessary points at the 70% and 100% flexibilizer levels to complete the comparison. With MDA then, we can show no improvement in strength at any concentration. But either flexible resin can perform its diluting function to lower the viscosity of an epoxy system, without great loss in flexural strength.

Two Properties Reduced

Flexibilizing an epoxy system sometimes brings disadvantages. The most obviously inescapable one is the reduction in heat distortion temperature, regardless whether one accomplishes this flexibilizing by inert additive, by flexible

Table 2. Electrical Characteristics—DER 331 plus Flexible X-2673.2

Diethylenetriamine Hardener	DER 331				70/30 Blend			
	Initial		48/23/96		Initial		48/23/96	
Frequency	K	DF	K	DF	K	DF	K	DF
60 cycles	4.19	.0162	4.35	.0208	4.14	.0208	4.10	.0348
10^3	4.09	.0239	3.92	.0306	3.98	.0269	3.93	.0293
10^7	3.30	.0310	3.51	.0300	3.13	.0319	3.33	.0386
Volume Res. 60s, ohm-cm.	3.1×10^{12}		1.0×10^{12}		1.1×10^{12}		1.1×10^{12}	

Methyl Nadic Anhydride-Benzyldimethylamine	DER 331				70/30 Blend			
	Initial		48/23/96		Initial		48/23/96	
Frequency	K	DF	K	DF	K	DF	K	DF
60 cycles	3.27	.0041	3.29	.0052	3.33	.0069	3.38	.0077
10^3	3.27	.0040	3.27	.0045	3.31	.0085	3.36	.0087
10^7	2.88	.0210	3.01	.0207	2.99	.0252	3.01	.0278
Volume Res. 60s, ohm-cm.	2.8×10^{12}		1.9×10^{12}		2.7×10^{12}		2.6×10^{12}	

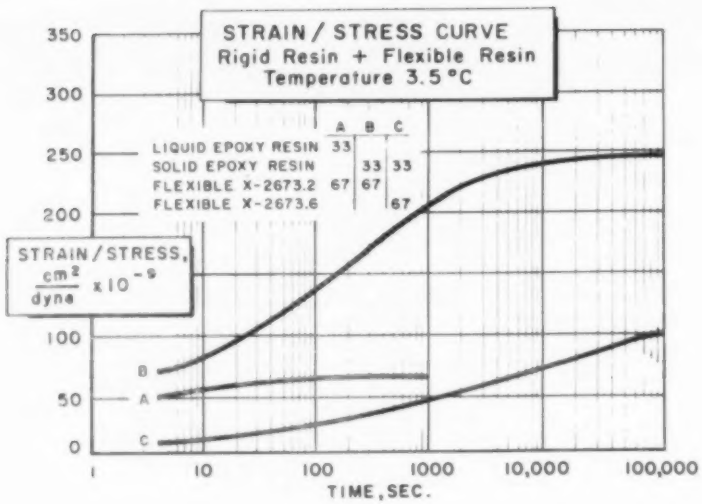


Figure 5. Attempts of experiments to make epoxy elastomers

hardener or by flexible epoxy. *Figure 4* shows the reduction in heat distortion temperature at various levels of Resin Point-2, the higher molecular weight, more efficient one, blended with D.E.R. 331. It is interesting and perhaps convenient that the three hardeners, divergent in character, reduce heat distortion temperature at about the same rate. If further experience with other hardeners should support this, it would simplify the rough prediction of loss of heat distortion temperature when using flexible additives.

Adding flexible modifiers to an epoxy resin may also detract from electrical properties. *Table 2* and our wider experience with related systems (1) show that 30% flexible resin can be tolerated, even under certain humid conditions. As with all flexible epoxy systems, electrical properties will undoubtedly fall off as the temperature rises. This will accelerate as each system approaches its individual heat distortion temperature (2).

A Slow Rubber

The prospect of developing epoxy elastomers has tempted the resin chemist for years. While we would like to think in terms of a snappy, fast rubber, only slow rubbers result when these flexible additives are raised to concentrations in the region of 70%. *Figure 5* pictures the results of some experiments on creep and recovery (3). Blends of flexible additive with liquid and solid epoxy resin and an amine hardener were cast and shaped to strips about 1/16 x 1 x 15 inches. These were stretched vertically by means of small weights, and their extension plotted as a function of time. The formulation containing 67% Point-2 resin in liquid epoxy, Curve A, reaches a rather low equilibrium very rapidly. We would expect this of a stiff system, relatively high in crosslinking. In Curve B, the liquid epoxy resin is replaced with a higher molecular weight, solid type. This keeps the content of hard, bisphenol-based resin constant, but reduces the frequency of crosslinking per unit volume. This system continues to extend, or creep to a much greater equilibrium elongation. Incidentally, for reasonable loads and short times at moderate temperatures, recovery is complete.

Curve C, replacing Point-2 with Point-6, supports our earlier contention that Resin Point-6 is a less efficient flexibilizer. Note that the curve approximates Curve B in shape, but the equilibrium extension will be less. However, switching from relatively long chain Point-2 (Curve B) to the short chain Point-6 (Curve C) flexible resin does not greatly stiffen the system; the equilibrium elongation will be reached slowly in both cases.

One observation is still puzzling. This is the initial decrease in mechanical strength observed as small quantities of flexible resin are added (see *Figure 3*). Even in other cases, where this did not show up at the 10% level, it might be found if we used smaller increments, perhaps 1-5%. For an explanation we might use the analogy of gelatin in a sponge. The sponge is the crosslinked network, and the gelatin represents linear polymer occluded in the network. Plasticizing slightly, chain slippage is eased, and mechanical stress easily brings the system to the rupture point of its dense network.

As the flexible resin content increases, some of the sponge network is destroyed, that is, crosslink density is decreased. The lightly crosslinked flexible system can now accept higher stresses without cracking, but of course at a greater total deflection.

Applications

Uses for these flexible epoxy additives are only partly explored. We expect them to cover the range of applications where improved toughness (non-brittleness) or true flexibility are needed, with the option of optical clarity and very light color. Castings and adhesives resistant to thermal and mechanical shock seem logical uses. Epoxy laminates might benefit from the toughening effect of low concentrations of flexible additive. We would expect this to result in improved ply bonding and greater edgewise compression strength. In coatings too, improved flexibility and impact resistance are known to result from the use of Experimental Resins X-2673.2 and X-2673.6.

Acknowledgment

The authors wish to thank Dr. Turner Alfrey, Jr., The Dow Chemical Company, for permission to use some of the unpublished results of his experiments on creep and recovery.

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Comparison of Plastisol Extrusion Coating with Conventional Coating Methods

Vinyl dispersions are normally applied to cloth and other substrates by roller or knife coating. A new method for applying these materials has been recently developed, involving plastisol extrusion lamination. Considerable interest has been shown in this process, particularly as to the economics of the extrusion method compared with older methods. This article looks at the new and old processes as a guide to where and how each should be considered

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Knife and roller coating methods, or post-fusion methods, are similar in that the plastisol (or organosol) is first applied to the substrate and is then fused into a film by heating. There are 3 basic types of knife coating systems. They differ in the position of the knife blade as shown in *Figures 1a, b,* and *c.*

Knife over Roll—The knife over roll is the simplest of the knife coating arrangements. The substrate is passed between the blade and the roll where the coating is spread on. Coating weight is controlled by adjusting the angle and height of the blade. High viscosity materials are easily applied to heavy substrates because of the supporting effect of the roll. Trouble is encountered when substrates which have an open weave are coated because the knife drives the coating through the cloth (commonly referred to as "strike-through"). Also variations in web thickness cause variations in coating weight in the finished product.

Unsupported Knife—The unsupported knife is positioned between a roll and a supporting member. The substrate passes over the roll, under the knife and over the supporting member. (The substrate is said to float under the knife hence the term "floating knife".) Coating weight is determined by both blade angle and tension on the substrate. Open mesh cloths can be coated without strike-through using this method. Knitted materials cannot be coated with this equipment because the tension required causes the fabric to curl under the knife.

Blanket Coater—This coater is actually a compromise between the two previous methods. An endless rubber belt is used as a support, and this prevents curling under the blade. Thus this method is used for coating knitted materials.

Reverse Roll Coating

The name reverse roll coating comes from the fact that the coating applicator roll revolves in a direction opposite to that of the web passing between the applicator roll and a rubber covered back-up roll. The amount of coating which is thus applied to the web by a wiping type action is controlled by the clearance between the applicator roll and another roll called the metering roll. Clearance between the latter two rolls is controlled by a micrometer screw for

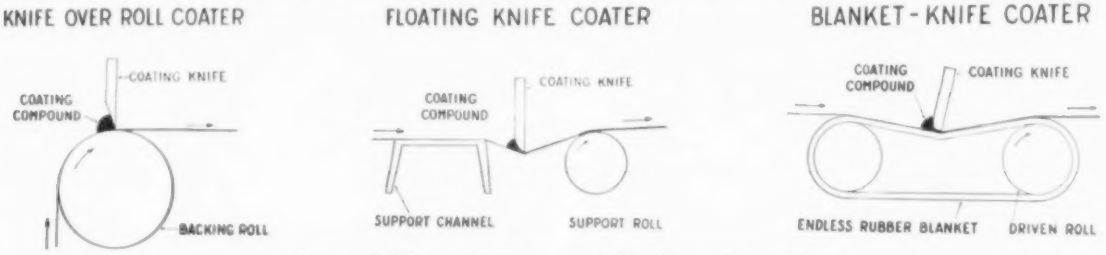

Figure 1. Three basic types of knife coating systems:

1a—knife over roll coater 1b—floating knife coater 1c—blanket-knife coater

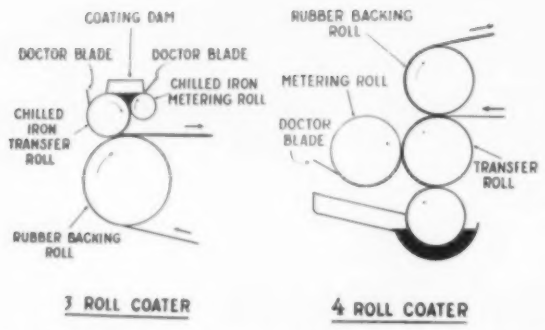

Figure 2. Roller coating-gauge control is more precise and requires less skill than for knife coating

accuracy. The amount of coating can also be controlled to some extent by the "wipe ratio"; that is, the relationship between the peripheral speed of the applicator roll and the web. This high "wipe ratio" will in effect pile up the deposited coating to a thicker film than that meter on to the applicator roll by the metering roll (*Figure 2*).

Due to the fact that the metering roll and the "wipe ratio" accurately control the applied film thickness, gauge control is more precise and requires less skill than for knife coating. Another advantage is that due to the method of applying the film to the web, differences in the thickness or smoothness of the web have no effect on the thickness of film applied. Although less critical than knife coating, the viscosity of the roll coating must be kept within reasonable limits, about 100,000 centipoises or less and generally more than 1000 centipoises. The viscosity anomoly of dilatancy is particularly troublesome in reverse roll coating. As in knife coating, many fabrics require a size coat before the body coat to control penetration and adhesion.

Extrusion Coating

Extrusion coating differs from spread and roller coating in that the plastisol is fused *before* it is applied to the web. The plastisol is pump-fed through a hot extruder screw, and out through a film die. Coating weight can be controlled by the extrusion rate and the web speed. Embossing can be accomplished in line as illustrated in *Figure 3*.

Because the coating is applied *after* fusion, the viscosity and flow properties of the unfused plastisol are less important. If the plastisol can be pumped, it can be extruded. Materials which cannot be coated by other means can be efficiently handled by this process.

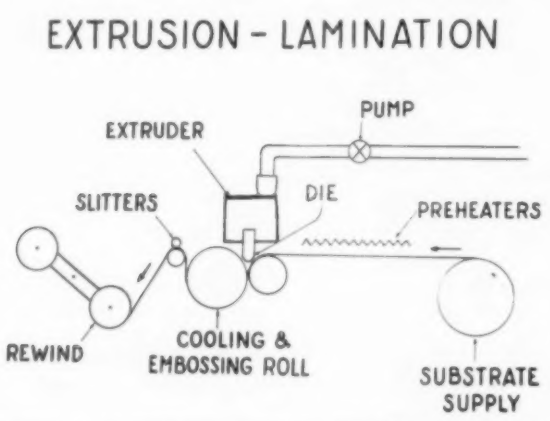

Figure 3. In extrusion coating, the plastisol is fused before it is applied to the web

The type of web (open or closed) also has little effect. Open-meshed materials, even scrim cloth, can be coated without strike-through problems. Surfaces to which vinyl does not adhere, such as metal, can be pre-treated with adhesive prior to lamination. Heat sensitive cloths, such as nylon, can be handled with minimum difficulty because the substrate is subjected to very little heat compared to where fusing takes place after coating.

Unlike polyethylene extrusion, where the material is relatively heat stable, exceptional care must be taken in designing the die to prevent stagnant areas which might result in decomposition of the vinyl.

Cost of Equipment

The following *table* compares the approximate total purchase prices of the required equipment for each process.

Comparison of Purchase Cost of Various Types of Plastisol Coaters

Knife Coating Line	Reverse Roll Coating Line	Extrusion Coating Line
Turret Unwind	Turret Unwind	Turret Unwind
Knife Coater	Reverse Roll	Radiant Preheat
Oper. Platform	Oper. Platform	Extruder & Die
Oven Rolls	Oven Rolls	Pump
Embosser	Embosser	Laminator (Rubber Roll and Embossing Roll)
Cooling Rolls	Cooling Rolls	
Web Guide	Web Guide	Turret Rewind
Turret Rewind	Turret Rewind	Pull Roll
Drives	Drives	Splice Roll
Oven	Oven	Winder and Laminator Drive
TOTAL PRICE*	TOTAL PRICE*	TOTAL PRICE*
$125,000	$135,000	$100,000

* NOTE: Approximate Price Totals

Note that these prices are approximate and will vary with features of the equipment.

Manpower

The manpower required to operate an extrusion coating line is about the same as that for roller or knife coating. In extrusion coating, an operator is required at the coating station to regulate the coating weight and substrate supply. A "back tender" is also needed who is responsible for inspection and wind-up of the product. There is a partial job for a third man who supplies raw materials and removes the finished product. Thus manpower does not enter into the economic comparison of the different coating methods.

Heat Costs

The extrusion coating process uses electrical heat which is conveyed to the plastic through metal. The post-fusion methods require hot air-ovens which are gas or oil fired—and are less economical. A typical 4½" diameter extruder line will require 70 KW to heat the extruder and die. This represents a cost of approximately *$1.00/hr.* for a 4½" line based on 1.5¢/KW-HR. A one hundred foot tunnel oven requires some 11,000 cu. ft. of gas/hr. which costs about $10/hr. Even when the cost of preheating the web is included (25 KW), heat costs about 1/7th as much in extrusion coating.

Drive Power Consumption for Motors and Fans

Both extrusion and oven methods require considerable electrical power to run motors which operate various mechanical parts of the equipment. For a 4½" extrusion line

the drive motor should be 40 hp. The fans required for the tunnel oven will also require about 40 hp. The other operations, wind up, etc. will also be equal in power consumption. Therefore, mechanical power needs will not influence the relative cost picture.

Floor Space

An important aspect in an economic comparison of manufacturing methods is the amount of plant space required for the installation. The width and height of the units for plastisol coating are comparable but the length of the oven in the roller and knife coating operations is considerably greater. The overall length of a typical extrusion coating line is 26 feet compared to 135 ft. for roller and knife coating lines. Thus, an extrusion coating line takes 80% less area than a roller or knife coating line. An exact dollar value of this floor space saving is very difficult to give. It depends on whether the area is available, where it is located and what type of building is involved. Floor space consideration must be based on the individual situation of each customer.

PRODUCTION RATES

Production rates for any equipment depend on the type of substrate and coating involved. This discussion is limited to ideal substrates such as paper and strip metal which do not have "strike-through" problems. Important points for this type of substrate are the rheological properties of the coating and the plastisol fusion capacity of the equipment.

Rheological Limitations

In extrusion coating the plastisol is applied to the substrate as a fused film. The only necessity is that the plastisol be fluid enough to pump to the machine. With knife and reverse-roll methods, the coating is applied by spreading the unfused material onto the substrate. Shear rates are often very high and viscosity levels at these high shear rates are of the utmost importance. This limits the formulation latitude, and knife and roller applied plastisols are often compromises between top physical properties and good coating behavior. It is common practice to control the viscosity of a spread-coated plastisol with small amounts of diluent. The presence of the diluent lowers the viscosity, but the maximum coating thickness must be limited to 4 or 5 mils per pass to prevent blistering. Rheological properties have little to do with extrusion coating performance, however. This is very important because coatings which will not spread coat can be well applied in this way.

Fusion Capacity

Fusion rate of the plastisols is determined by the heat transfer capacity of the coating equipment. A plastisol fuses when the plasticizer dissolves the resin. With most plastisols, this occurs about 350°F. The extrusion process uses a combination of heat transferred from the extruder barrel and mechanical heat made by the screw working the material. The production rate desired will, of course, greatly influence the choice of suitable extrusion equipment. The following data gives typical extrusion capacities and web speeds for various size extruders.

Web Speed, FPM @ Different Film Thicknesses (60" Wide)

Extruder Size	Extrusion Rate	2.5 mil	5 mil	10 mil
4-½" Diam. Machine	400 lb/hr.	80	40	20
6" Diam. Machine	800 lb/hr.	160	80	40

The tunnel oven used in other coating methods depends on heat transfer from hot air to the coating. Thus coating speeds depend on the size and temperature of the oven. A speed of 150 ft./min. for a 4 mil coating is about the maximum commercially feasible on a roller coater. Faster speeds will generally require excessive oven length (300 ft. or more).

QUALITY AND LIMITATIONS

Gauge Control

Gauge control in the extrusion process is determined by the opening of the die. It is possible to adjust the die to 20 mils ± 0.5. The 20 mil film coming from the die is drawn down to the desired thickness by adjusting the laminator speed. The gauge variation in the 20 mil film is reflected in the final film thickness in proportion to the drawdown ratio. Better gauge control can be obtained with a roller coater.

Bond and Adhesion

The extrusion coating method does not produce the bond or adhesion strength obtainable from the post fusion methods. This is because the prefused film does not wet the substrate as well as the fluid plastisol. Primers, though, can be used to improve adhesion. Preheating the substrate also greatly increases adhesion.

Web Widths

In extrusion coating, the web width is determined by the die. To date, 60 inches is as wide as present art will allow with vinyl. Unlike polyethylene extrusion, deckle rods are not usually used to reduce the web width when running vinyl compounds. This means a die must be the correct width for the substrate. If desired, several substrate widths may be coated simultaneously to comprise the width of the die.

Spread coating systems are more versatile when varying widths are encountered. This is done by using side dams on the coater which restrict the coating to the area being covered.

Color Change

Color changes require careful procedures in extrusion coating. Two methods are available. Purging can be used if darker colors are to follow lighter colors. Best results are obtained by cleaning the die, however. Where production cannot be delayed for cleaning, interchangeable dies are recommended.

In roller and knife coating, the cleaning operation is simpler because the plastisol is not fused in the coater and all contaminated areas are exposed.

Conclusion

Extrusion coating of vinyl plastisols offers some distinct advantages over knife and roller coating methods. These stem from the fact that extrusion coated plastisols are applied in a fused condition. The advantages include:

1. Capital investment in equipment is lower.
2. Savings in floor space and power consumption.
3. No subsequent heating steps are required.
4. "Strike through" problems are nonexistent.
5. Rheological problems are not as critical—giving greater formulation latitude.

On the other hand, extrusion coating does not have the gauge control of roller coating, and adhesion must be promoted with primers in some cases. However, any plastisol coater should at least consider the plastisol extrusion process before purchasing new coating equipment.

The Promotion and Retardation Of Cross-Linking in Thermally Processed Polyvinyl Chloride Systems

How various compounds affect cross-linking—
- *Zinc Compounds—strong*
- *Phenolic compounds—weak*
- *Amines—generally strong*
- *Phosphites—mild*

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This article reports experimental extension and elaboration of a previously published communication on the theory of stabilization of systems containing poly (vinyl chloride) (PVC) (1). In the earlier article a theoretical mechanism was deduced from observations on thermal degradation of PVC which involved a distinction between dehydrochlorination of vicinal carbons on the PVC chain, (designated *para*dehydrochlorination), and dehydrochlorination of non-vicinal carbons of the same or different chains, (designated *dia*dehydrochlorination).

An essential element of the theory as published was the directive influence which certain stabilizing compounds had on the balance between para- and dia-dehydrochlorination.

For the purposes of this study the degree of dia-dehydrochlorination will be considered as essentially proportional to the degree of cross-linking (i.e. the ratio of cross-links to rings is presumed not to vary significantly). It is further assumed that the tendency of PVC to swell in solvents, rather than to dissolve, is related to cross-linking, viz:

Highly cross-linked polymers do not swell as much or as fast as less highly cross-linked polymers. Polymers which have no significant degree of cross-linking dissolve.

The systems examined here involve, in all cases, plasticized compositions.

They were chosen to illustrate the susceptibility of the cross-linking reaction to the directive influence of additives.

The degree of cross-linking may vary with the type and amount of plasticizer, and with the heat history, as well as with the nature of the additive.

Procedures for Swelling Tests

Two approaches were used in the observations on cross-linking.

The strong-solvent technique. This approach to the problem may be regarded as essentially *thermodynamic* in outlook, since it is concerned with an equilibrium condition —the ultimately swollen state—and no attention is paid to the rate of swelling. The simple correlation here assumed is that the more highly swollen state is less highly cross-linked. Here a polymer solvent (tetrahydrofuran) was added to the heat-aged plasticized PVC and observations made on the solution or swelling of the sample. In these cases samples which were not cross-linked were completely dissolved. Those which were slightly cross-linked increased in volume many times forming a weak, enlarged model of the shape of the original sample. Those which were highly cross-linked did not swell as much. In all cases the ultimate size appeared to be attained in 3-4 days.

The poor-solvent technique. This second approach to the problem is to be regarded as essentially *kinetic* in outlook, since it is concerned with rates of change, with less attention paid to the state of ultimate distention. The simple correlation here assumed is that the more highly cross-linked substance reduces the penetration rate of an external liquid phase. Here a poor solvent (gasoline) was added to the heat-aged plasticized PVC. Samples which were only slightly cross-linked swelled rapidly and then tended to contract or remain constant in volume. Highly cross-linked samples swelled more slowly, and did not, within the duration of the tests, attain an equilibrium size.

Tests on swelling in tetrahydrofuran—the formula

100 parts plastisol resin (Bakelite QYNV)
100 parts di(2-ethylhexyl)adipate
1 part of additive

The product was mixed mechanically for 10 minutes at room temperature, then poured into covered aluminum dishes to a depth of about 1 cm. and heated at 350°F for 8 or 24 hours in a forced convection oven. A sample of the product, ¼" x ½", was then cut from the heat-aged plastisol, and placed in a jar of tetrahydrofuran which was then tumbled for several days. The sample was measured.

Table 1. Effect of metal-containing compounds on swelling of heat-aged plastisols

Additive	Logarithmic swelling factor After 8 hrs. heating	After 24 hrs. heating
1. None (control)	1.5	0.8
2. Salts of carboxylic acid and phenols		
a) Zn naphthenate (Solution contg. 8% Zn)	0.4	0.2
b) Ba naphthenate (Solution contg. 11% Ba)	1.4	0.6
c) Cd 2-ethylhexoate (Solution contg. 14% Cd)	1.3	0.9
d) dibasic Pb stearate	1.1	0.9
e) Pb naphthenate (Solution contg. 24% Pb)	1.3	1.0
f) dibutyl Sn dilaurate	1.4	1.1
g) Ba octylphenolate (Solution contg. 14% Ba)	1.2	1.1

Table 3. Effect of nitrogen-containing compounds on swelling of heat-aged plastisols

Additive	Logarithmic swelling factor After 8 hrs. heating	After 24 hrs. heating
1. None (control)	1.5	0.8
2. N-containing compounds		
a) N,N′-diphenylphenylene-diamine	0.4	0.1
b) diphenylguanidine	0.2	0.3
c) thiocarbanilide	0.4	0.1
d) monoethanolamine	0.7	0.3
e) aniline	0.8	0.4
f) N,N-dimethylaniline	0.6	0.6
g) 2,6-diethylaniline	0.6	0.1
h) diphenylurea	0.8	0.3
i) 8-hydroxyquinoline	1.0	0.7
j) butyraldoxime	1.2	0.9
k) p-n-dodecylamidophenol	1.2	0.8

For purposes of facility in comparison, a logarithmic swelling factor is used. This factor is defined as the $\log_{10}$ (swollen volume/initial volume).

The effects of various additives are shown in *Tables 1-4*.

In *Table 1*, it appears that only the Zn compounds exert strong cross-linking effects. The other metallic compounds exert only a slight cross-linking effect (vs. control) in 8 hours heating, and, in some cases a inhibiting effect (vs. control) in 24 hours heating.

From *Table 2*, it appears that none of the phenolic compounds affected cross-linking profoundly. Possibly isopropylidene bisphenol may have retarded early cross-linking, while *p*(1,1,3,3-tetramethylbutyl) phenol may have accelerated it on prolonged heating.

From *Table 3*, it is observed that amines generally exert a strong cross-linking effect. Compounds related to urea in structure were also effective cross-linkers.

Table 2. Effect of phenolic compounds in swelling of heat-aged plastisols

Additive	Logarithmic swelling factor After 8 hrs. heating	After 24 hrs. heating
1. None (control)	1.5	0.8
2. Phenolic compounds		
a) p(1,1,3,3-tetramethyl-butyl) phenol	1.4	0.5
b) p-nonylphenol	1.6	0.8
c) α-naphthol	1.4	0.9
d) β-naphthol	1.4	0.9
e) hydroquinone	1.6	0.9
f) resorcinol	1.4	0.8
g) resorcinol monobenzoate	1.5	0.9
h) 1,4-dihydroxyanthra-quinone	1.3	0.9
i) 4,4′-isopropylidenebisphenol	1.8	0.9
j) bis (p-1,1,3,3-tetramethyl-butylphenol) sulfide	1.5	0.9
k) 4,4′-thiobis (6-tert. butyl-metacresol)	1.3	0.7
l) 2-hydroxy-4-methoxyben-zophenone	1.6	0.9
m) butylated hydroxy anisole	1.3	0.9

Table 4. Effect of epoxy- and phosphorus-containing compounds on swelling of heat-aged plastisols

Additive	Logarithmic swelling factor After 8 hrs. heating	After 24 hrs. heating
1. None (control)	1.5	0.8
2. Phosphorous containing compounds		
a) triphenyl phosphite	1.1	0.8
b) tri(2-ethylhexyl)phosphite	1.2	1.0
3. Epoxides		
a) epoxidized soya bean oil	1.3	0.7
b) styrene oxide	1.3	0.7
c) epoxy resin (condensate of 4, 4′-isopropylidene bisphenol with epichlorohydrin)	1.4	1.0

From *Table 4*, it appears that the phosphites have a mild cross-linking effect in the early stages of heating.

On prolonged heating the tri(2-ethylhexyl) phosphite and the epoxy resin inhibit cross-linking.

To assess the rate of cross-linking, as a function of time and temperature, with a highly cross-linking reagent, a series of tests were run using N,N′-diphenylphenylenediamine as the cross-linker in the di(2-ethylhexyl) adipate-containing plastisol. The oven aging was conducted at 365°F (185°C).

It is evident (*Table 5*) that rate of cross-linking is increased by concentration of the cross-linking agent, and that the extent of cross-linking is increased by prolonged heating. While precise quantitative conclusions are not warranted by the data, it appears that the addition of 0.5-2.0 phr of

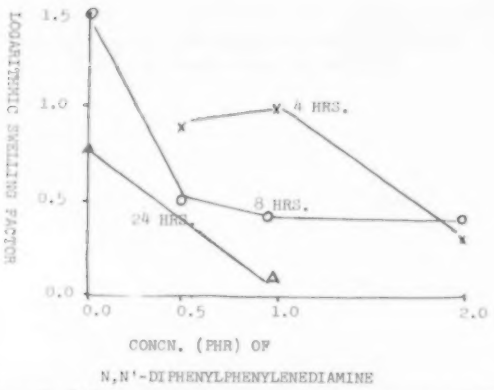

Figure 1. Effect of additive concentration on swelling of plastisols at various durations of oven aging at 350°F. (177°C.) Increasing concentration of the amine, and more prolonged heating decreases swelling

the additive increases the rate of cross-linking by a factor of about 5 to 10. Data of *Table 5* are shown in *Figure 1*.

The observation that Zn-containing compounds are powerful cross-linkers while Cd- and Ba- containing compounds are not so effective was tested for validity in formulations which more closely approximate calendered products in plasticizer content.

In the series of tests included in this report swelling was measured in gasoline, rather than tetrahydrofuran.

The additive in the cases given in this article were Ba, Cd or Zn stearates, or 1:1 (by weight) mixtures of these soaps. Additive weight was kept constant at 1 phr.

Each mixture was milled for 5 minutes at 320°F on a 2 roll mill, to a thickness of about 40 mils. Small square coupons of the milled sheet were cut and placed in individual aluminum foil dishes, which were then heated in a forced convection oven for 2 hours at 365°F. (185°C). The entire series of experiments was repeated at 375°F (191°C).

The weight losses in the oven corresponded to about half the plasticizer weight, less at lower temperatures.

The oven-aged samples were then tumbled in small individual jars for varying periods of time at room temperature. Prior to weighing, each sample was wiped dry, and any observed occlusions of liquid were pressed out.

Because of the much lower swelling tendency in these experiments when compared to those noted previously,

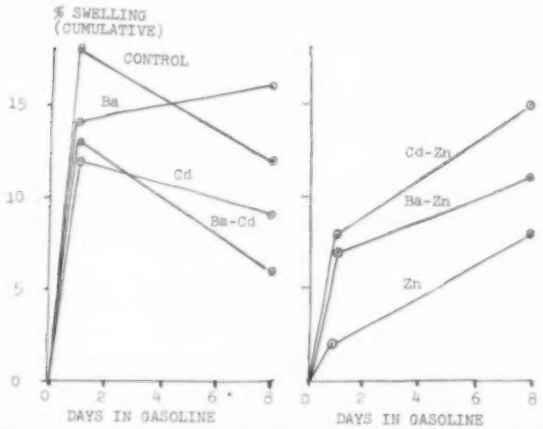

Figure 2. Effect of stearate additives (1PHR) on swelling in gasoline of moderately plasticized PVC, oven aged for 2 hours at 365°F. (185°C.)

Formulations for Tests on Swelling in Gasoline

A (moderately plasticized)	B (poorly plasticized)
100 parts calendering resin (Geon 101)	100 parts calendering resin (Geon 101)
40 parts di(2-ethylhexyl) phthalate	20 parts di(2-ethylhexyl) phthalate
1 part additive	1 part additive

swelling is recorded here simply as % weight gain per day. The swelling rates in gasoline of the various systems are shown in *Figures 2-5*.

The observations in the box support the concept that cross-linking is more likely to occur when the polymer molecules are more closely packed (at low plasticizer content); but even at high plasticizer content Zn compounds specifically favor the cross-linking reaction.

Contraction after initial swelling in non-Zn stabilized systems of moderate plasticizer content suggest that the looser cross-linking pattern which permits greater initial swelling permits also a gradual leaching out of some plasticizer. The loss of plasticizer may after a while be greater than the influx of gasoline.

Discussion

Cross-linking as detected by reduced or retarded swelling implies the existence of tertiary or quaternary carbons along the polymer chain, where the cross-link is presumed to be a C-C bond.

It is impossible for quaternary carbons to be members of conjugated double-bond structures (since they have, ipso facto, two adjacent single bonds). It is improbable that, in degrading vinyls, tertiary carbons will become units of a conjugated double-bond system. This is true because double-bonded carbons are attached only to adjacent carbons on the same chain, and to hydrogens. Cross-linking these double-bonded carbons to form conjugated tertiary carbons requires dehydrogenation, a reaction thus far not encountered in the normal processing of vinyls. Therefore, to the extent to which the color of degrading p.v.c. is attributable to conjugated structures, cross-linking represents a means for preserving the color of vinyls.

In the case of nitrogen-containing compounds, early cross-linking is most pronounced in structures in which there is at least two functional nitrogen groups. This suggests that the nitrogen compound itself forms the link between the polymer chains, instead of establishing the direct linkage of chain carbon-to-chain carbon. The resulting links are weaker in that the C-N bond energy is less than that of the C-C bond. However, the introduction of additional atoms

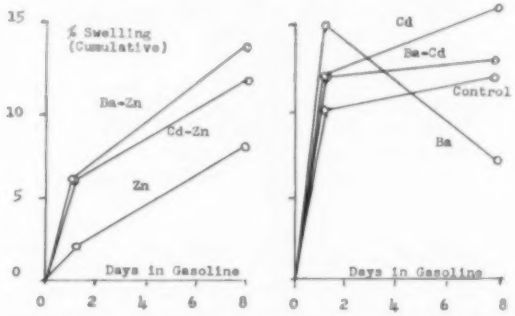

Figure 3. Effect of stearate additives (1PHR) on swelling in gasoline of poorly plasticized PVC, oven aged for 2 hours at 365°F.

Generalized Observations on Swelling

1. Systems containing Zn have invariably lower initial swelling rates than those which do not contain zinc.
2. Systems containing Zn stearate (without Ba or Cd) have low initial swelling rates, independent of the initial plasticizer content.
3. Systems other than those containing 1 phr Zn stearate have reduced initial swelling rates at lower initial plasticizer concentrations.
4. Systems containing Zn have long-term swelling rates which are less dependent on initial plasticizer content than are systems which do not contain zinc.
5. Systems containing no Zn have low, or negative long term swelling rates in moderately plasticized systems, and high long term swelling rates in poorly plasticized systems.
6. There is no appreciable change in swelling characteristics between oven aging at 365°F. and at 375°F.

into the link between the chains provides additional degrees of mechanical freedom. Therefore, the likelihood of rupture of nitrogen-induced cross-links involves positive and negative factors, compared with Zn-induced cross-links.

Experience in vinyls suggests that the sudden intense color formation in some formulations containing Zn are not duplicated in the nitrogen systems. However, secondary color-forming reactions, characteristic of nitrogen compounds per se, often obscure the course of degradation.

Analogous types of cross-linking are known in other polymers, such as in epoxy resins.

The cross-links are however points of constraint on the free movement of the molecules. On heating, or by mechanical shear, polymeric molecules with cross-link restraints are more likely to rupture than are molecules not subject to such restraint. But such rupture creates a condition favorable to free radical degradation.

Free radical degradation is likely to be very rapid, and is also likely to involve rapid oxidation. The resulting polyene structures, with carbonyl groups possibly in conjugation may be darkly colored. Therefore agents promoting cross-linking in vinyls are likely to be characterized by delayed sudden and intense color changes. This conforms with industrial observations on many stabilizing systems containing zinc.

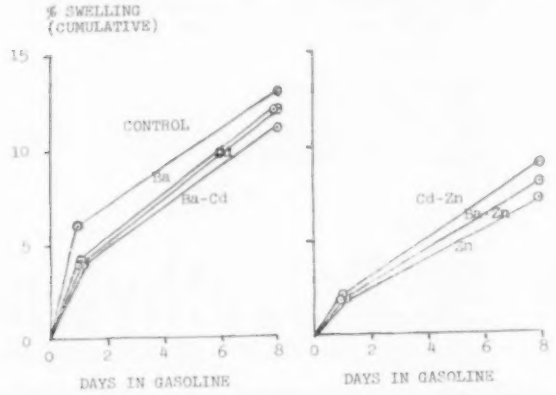

Figure 4. Effect of stearate additives (1PHR) on swelling in gasoline of poorly plasticized P.V.C., oven aged for 2 hours at 365°F. (185°C.)

Table 5. Effect of concentration of N,N'-diphenylphenylenediamine and of duration of heating on the logarithmic swelling factor of oven-aged plastisol

Concentration (phr)	Heating period (hours) 4	8	24
0	*	1.5	0.8
0.5	0.9	0.5	*
1.0	1.0	0.4	0.1
2.0	0.3	0.4	*

* Not determined.

The cross-linking in polyethylene exposed to ultraviolet light, or to more intense radiation, proceeds by free radical mechanism to cross-links involving tertiary and perhaps quaternary carbons. In polyethylene however, there does not exist, as a significant alternate, the stripping of hydrogens from the chain to form a polyene structure. In vinyls, the dehydrochlorination along the chain is an easily induced reaction. Therefore in polyethylene, the cross-linking reaction does not result in intense color formation regardless of the duration or intensity of subsequent energy input. But in vinyls, the color forming reaction which was blocked by the cross-link is initiated and greatly accelerated by the breaking of that link.

The directive tendency of some additives in vinyls to promote *dia*dehydrochlorination vs. *para*dehydrochlorination has been demonstrated. It is one mode but not the only mode of cross-linking. The theoretical consequences of such directive tendencies is believed to be consistent with industrial experience in vinyls.

Literature References

1. The basic paper was presented at 15th ANTEC, SPE, New York January 1959: "A New Theory of Stabilization of Mixtures Containing Polyvinyl Chloride", by Fuchsman, C. H. This paper, in editorially condensed form appeared in SPE JOURNAL, September, 1959 pp. 787-90 under the title "Stabilization of Mixtures Containing Polyvinyl Chloride."
2. An example of study of polyvinyl chloride swelling as a property of a cross-linked system is to be found in: "Determination of Polymer-Liquid Interaction by Swelling Measurements" by Doty, P. and Zable, H. S. pp. 440-456 of "*High Polymer Physics*" (ed. Robinson, H. A., Chem. Pub. Co., Brooklyn, New York 1948.

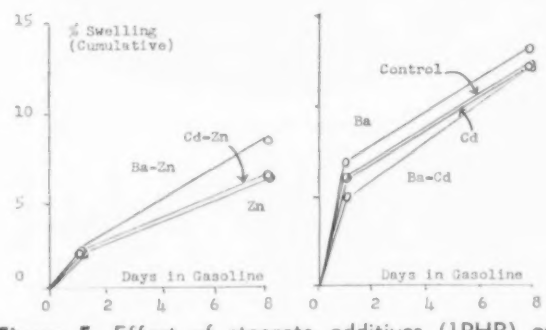

Figure 5. Effect of stearate additives (1PHR) on swelling in gasoline of poorly plasticized PVC, oven aged for 2 hours at 375°F. (191°C.)

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Edward Ferrari
Chairman, Casting and Plastics Tooling PAG
(General Electric Co.)

PAG Progress

Casting and Tooling PAG to Develop Application Information For End User

The Annual Business Meeting of the Casting and Plastics Tooling Professional Activity Group held during the Annual Technical Conference in Washington, D. C. was highly stimulating and rewarding. Opened by Chairman Lawrence Wittman and attended by more than twenty people, the meeting was immediately directed into an open forum consisting of a panel to whom questions were addressed. The panel comprised Chairman Wittman, Earl Sumner, Donald Prideaux and Edward Ferrari. Many questions and problems relating to the casting of tools, models, prototypes and production parts were discussed for over three hours. At the conclusion of the discussion period, the Officers for 1961 were introduced by the Chairman to the members. Plans were then formulated for participation of the Group in the forthcoming 18th ANTEC. Subjects were chosen from the discussion period and several members volunteered to develop them into technical papers to be submitted to the SPE Technical Program Committee for presentation at the next Annual Technical Conference.

Results of this and previous Group meetings bring forth certain fundamental facts concerning casting and tooling resins and their applications. Most evident and perhaps most important is that although there is an ever increasing amount of data concerning the properties of the resins, there is very little related detailed technical information on the application of these materials to the many end uses. The supplier and the compounder alike have made many contributions in furnishing basic procedures for applications of materials particularly useful in the plastics tooling field. Some of this information is relevant to the many processes of casting plastics as it is defined, i.e. pouring liquid resin into a mold and curing to a solid state which registers and retains mold contours after removal from the mold.

The early work done in this area was almost entirely accomplished by the end user. Since he had no previous experience from which definite procedures could be established, this application research remained for a time in the category of an art. With time and experience, definite data and procedures have been established by various groups according to their own particular necessities. Much of this development has, however, remained strictly proprietary information. One fact became evident during the forum and discussion period—mainly that each group is seeking the answers to common basic problems. This is the reason for the existence of a PAG where opportunity is offered at the Society level "to work together in the solution of specific problems in a specific field".

It is obvious that the long range objective of the Casting and Plastics Tooling PAG is to establish a common ground where basic knowledge can be converted into fundamental principles and processes employed in the end application. To meet this need the following projects have been undertaken by this PAG:

A. A committee has been established to assist the Technical Program Committee in soliciting and screening abstracts and papers for the 18th ANTEC.
B. A bibliography was compiled and published in the May issue of the SPE Journal (p. 478). The result of several years of work on the part of the committee and the members of the PAG, the bibliography is extremely comprehensive. It is hoped that it will periodically be augmented and revised and it has been suggested that in the future the subject matter be abstracted.
C. Four members of the PAG have volunteered as a committee to gather all data pertinent to "exotherms, how they effect the shrinkage from the mold dimension and how to control or minimize this to include defining chemical and thermal type shrinkage." This project was the direct result of the ANTEC panel. Also two members have offered to write up the pro and con discussion on "Tools for Casting", to be printed and circulated among the PAG members.
D. Assistance was given to the American Society of Tool and Manufacturing Engineers for its "Plastics for Tooling" Seminar in Detroit, on March 15, 1961.

Officers of the Casting and Plastics Tooling PAG for 1960:

Chairman—Lawrence Wittman
(Lawrence Wittman Co.)
Sub-Chairman—Casting
Edward Ferrari
(General Electric Co.)
Sub-Chairman—Tooling
Donald G. Prideaux
(Rezolin)
Secretary—Earl C. Sumner
(The Duriron Co.)

The following Officers were elected for 1961 at the 17th ANTEC:

Chairman—Edward Ferrari
(General Electric Co.)
Vice Chairman—Richard L. Wheeler
(Jones Dabney)
Secretary—Donald G. Prideaux
(Rezolin)

Edited by **Saul Gobstein**, *Chairman PAG Executive Committee (Ferro Chemical)*

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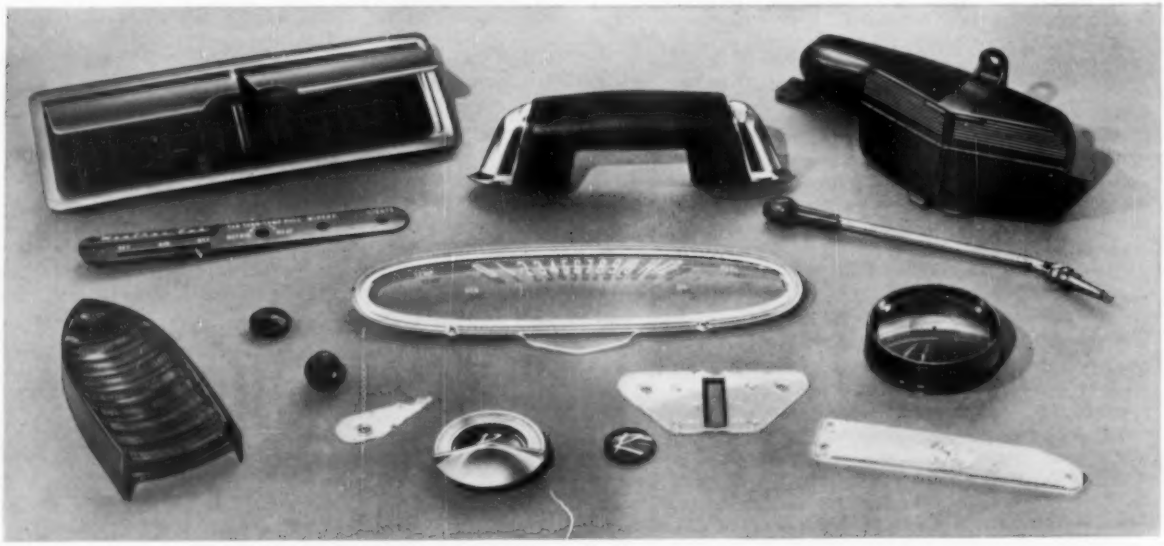

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PLEXIGLAS is used for tail light, back-up and parking light lenses because of its outstanding *optical properties* and *weather resistance* . . . for the speedometer dial because it calls for *edge-lighting* . . . for medallions and other ornaments because the *crystal clarity* of PLEXIGLAS gives depth and sparkle to the back-surface decorations.

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Detroit Representative: *R. C. Oglesby, Nor-Way Building, 20211 Greenfield Road, BRoadway 3-0674.*

SOCIETY ACTION

Administrative Board in Action

John Delmonte, *SPE Vice President, Administration, and Chairman, SPE Administrative Board, (Furane Plastics, Inc.)*

The regrouping of SPE functions under an Engineering Board and an Administrative Board was implemented by SPE Council action of October 1960. While there can be no complete separation of engineering and administration functions, discussions at Executive Committee and Council provide the climate for coordination of Society functions.

An examination of the current SPE organization chart published on page 161 of the February 1961 issue of the SPE Journal, points out the important functions of the Administrative Board. The functions of finance, membership, sections, public relations, credentials, constitution and by-laws, represent areas of administrative jurisdiction. The SPE is particularly fortunate in having available for service on these committees, dedicated men with a genuine flair for performing their job in the best interests of the Society.

To the SPE members and the old-timers who have accorded many years of interest to SPE affairs, a brief review or status report of the committees involved is always of interest. A few problem areas will be underscored because, as a truly democratic organization, we solicit assistance from interested SPE members. After reviewing these resumes, we hope that, if you have useful and constructive suggestions, you will write to the chairman of the committee involved with your ideas, or, communicate with your section's Councilman.

Communications with, and co-ordination of the various committees of the Administrative Board are under the capable direction of Sherman Crawford and Donald Eells, Vice Chairmen and Committee Administrators of the Administrative Board.

Finance—R. K. Gossett, Chairman—The SPE is fortunate in having one of its former Presidents serving as chairman of the Finance Committee. As a growing organization faced with increased membership and further implementation of engineering services and publications, finances are of prime concern. Projected income and expense are carefully budgeted. The Finance Committee is concerned with improvement of the income/expense ratio, which declined slightly during recent adverse business trends.

Public Relations—F. C. Sutro, Chairman—Another SPE Past President, co-ordinates the important areas of public relations. News-worthy functions taking place in many quarters, are receiving due attention in important news outlets.

Nominations—As the immediate Past President of the SPE, George Martin functions as Chairman of the Nominating Committee. Long active in Society affairs, George understands the needs of the organization.

Membership—Joe Grenier and his group spark the activities of the key Membership Committee. Those attending the recent ANTEC in Washington, D. C., could not help but be impressed by the drive and activity of Joe Grenier and Sherman Crawford on new member solicitation and promotion. Throughout the country the assistance from Regional Membership Chairmen are contributing towards the goal of 10,000 members by 1962.

Student Membership—Dr. Russell Ehlers has effectively demonstrated the establishment of a Student Chapter of the SPE. In heading-up these activities for the Society, he is transcribing his invaluable experiences into a useful procedures guide. Student visitation programs have been planned by many SPE sections.

Credentials—Ross Dean, as Chairman of the Credentials Committee, has done an outstanding job in organizing procedures for reviewing applications for SPE Membership and classifying membership grades. This is one of the "behind the scenes" committees which is seldom in the limelight, but which contributes effectively to the character of the SPE organization. The Credentials Committee is now evolving detailed procedures.

Sections—Ray Hauser, serving as Chairman of the Sections Committee, has the important responsibility of implementing the Section's Procedures Manual developed by Palmer Humphrey and his group in previous years. Sections, established throughout the world, have organization and operating problems of a generic character. The Sections Committee channels information and assistance for proper functioning.

New Sections—Paul Kelly, who is centrally located in the United States is Chairman of the New Sections Committee which has the important function of assisting and encouraging the development of New Sections of the SPE. Paul has a thorough understanding of procedures involved in establishing New Sections and is geographically well situated to assist in the formation of budding new sections.

Constitution and By-Laws—Robert Sherman, Chairman of the Constitution and By-Laws Committee, through careful planning and clear thinking, has documented the recent changes in the Constitution, By-Laws, and Rules of the SPE for Council action. Ably assisted by George Martin as Parliamentarian and Arthur Logozzo, Co-Chairman of the Constitution and By-Laws Committee in 1958, the extensive changes brought about by reorganization have required steady hands and careful documentation. The changes brought about during the past year have introduced unusually weighty responsibilities to the Constitution and By-Laws Committee.

Staff—Although SPE affairs have been handled by well organized committees, the co-ordination and support from SPE Executive Office staff give strength to the Administrative Committees. Their experience and guidance make the tasks much simpler.

In summary, the Administrative Board in Action reflects the energies and efforts of many capable individuals. The growth in both membership and quality of engineering meetings is a true measure of the effectiveness of these individuals.

—■—

edited by **Thomas A. Bissell,** *SPE Executive Secretary*

NEW BOOKS

EPOXY RESINS; MARKET SURVEY AND USERS REFERENCE

Prepared for industry by Harvard Business school graduate students (Materials Research, Cambridge, Mass., 1959. 175 pp. plus long appendix $18.50)

This monograph gives the essential practical data on the properties and uses of epoxy resins in industry. It is especially directed to manufacturers who by the incorporation of epoxy resins in their products or by the use of epoxy tools, coatings, laminates or adhesives, can improve the quality of their products and/or increase their profits substantially.

After an introduction in which the properties and uses of epoxy resins are described, the authors give estimates on their market, production, and study formulation and competition. Then they review all uses in detail in regard to maintenance, flooring, transportation, packaging, appliances, highways, housing, military requirements, textiles and many others.

The last chapters are devoted to the future of epoxy resins in the industrials described before. In the long appendix, the reader will find costs and returns, a glossary, a directory of formulators in each industrial field, a bibliography and a list of contributors. Decidedly a "must" to everyone using or planning to use epoxy resins.

Dr. Louis C. Barail
Barail Associates

ORGANIC COATING TECHNOLOGY, Vol. II

Henry Fleming Payne (John Wiley & Sons, Inc., 694 pp., $17.50)

Volume 2 of this work subtitled "Pigments and Pigmented Coatings," is devoted about one-half to a discussion of the various types of pigments and their characteristics and the balance to formulation and production of pigmented finishes such as paints, enamels and lacquers.

Of particular interest to those in the plastics industry are the sections on color pigments, white pigments, extenders and black pigments. They are written from a practical viewpoint which provides a maximum of information in a minimum of space. The author has the ability to present information in a straightforward, easily understandable manner which makes it possible for those not expert in the field to readily digest important facts. At the same time, he does not compromise with proper scientific principles. There is a good balance between theory and application, particularly in the case of color pigments.

This work covers all essential phases of a subject, listing the contributions which have been been made in each area with a complete bibliography. Recent developments in the field as well as older work are presented.

While the book is slanted for the paint industry, it does such an excellent job of discussing pigments in general that it is sure to be of value to workers in other fields.

H. F. Schwarz
Sherwin-Williams Co.

EXPERIMENTAL PLASTICS

C. A. Redfarn and J. Bedford, Interscience Publishers Inc., 140 pp., $4.25.

A collation of experiments in applied polymer science, this book is designed to provide the polymer chemist and plastics technologist with the gamut of laboratory exercises. It fulfills a definite need for an adequate treatise of this kind by both student and teacher in the plastics field.

The experiments are grouped in four sections, arranged in logical sequence, permitting the student to carry a product through the progressive stages of resin and polymer synthesis, compounding, processing, and evaluation. Performance of the individual experiments in numerical succession is advisable as directions for proper manipulation of apparatus and equipment given in introductory investigations are not repeated. The instructor will find designated hold-over points at which experiments can be interrupted until the next class, helpful in planning the lab schedule.

Due to the authors' attempt to condense four broad areas of polymer science into 140 pages, the omission of important basic experiments restrict its usefulness as a text for advanced study. Furthermore, there might be difficulty in interpreting British terminology and locating cited references.

However, as a laboratory reference text, Experimental Plastics would be worthwhile.

Russell W. Ehlers
Professor, in charge of Department of Plastics Technology

ANALOGUE COMPUTATION

(4 volumes)

Stanley Fifer, McGraw-Hill Book Co., Inc., 1370 pp., $39.50.

This latest textbook on Analog Computation by Stanley Fifer and published by McGraw-Hill is divided into four volumes. The first and second volume deal primarily with the general purpose D. C. functional computer elements such as operational amplifiers, multipliers, recorders, etc., with particular attention being given to the theory and operation of these elements. Volumes three and four contain an extensive treatment of the various types of computers and the many techniques that have been used over the past 10 or 15 years.

An excellent reference for analog computer specialists working in military and aeronautical fields, the text appears to be the result of a lengthy compilation made over several years of many technical papers on this subject (extensive references are given at the end of each chapter). Unfortunately, very little effort is made to distinguish between the techniques and hardware currently in use and those that have been discarded. There are many sections that should have been segregated in a volume, dealing solely on the "History and Development" of Analog Computation. A classic example of this is the mechanical differential analyzer, dealt with in some detail in the book, but today is considered to be a museum piece rather than a computing device. A neophite, reading this text in the hope of gaining knowledge on this subject will be left with a confused and erroneous picture of the modern analog field. Furthermore some of the recent developments in dynamic memory and analog-digital hybrid computation are not covered.

(Continued on page 600)

You
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LOOK CLOSELY at the hands above! Note how little of Ferro's *non-dusting* pigment has rubbed off in handling the resin-colorant mixture at the right. These unretouched photographs show its superior adherence to the granules as contrasted to the use of ordinary pigment in the mixture on the left.
But, suppose you make the test for yourself! Better yet, try Ferro's new pigments in your production and see what a big difference they make. You'll find they improve color dispersion, prevent troublesome dusting, save time and money in several ways.
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NEW BOOKS

Engineers working in the industrial processing fields who are curious about the purpose and application of analog computation that is rapidly springing up in various sectors of civilian industry will not satisfy their curiosity with this text. The examples that are used to demonstrate the techniques deal mainly with flight and vibrational problems.

Roger G. E. Franks
E. I. du Pont de Nemours & Co., Inc.

TABLES FOR IDENTIFICATION OF ORGANIC COMPOUNDS

Charles D. Hodgman, et al (The Chemical Rubber Co., 240 pp., $7.00)

This book is the supplement to the Handbook of Chemistry and Physics published by the same publishers. The first set of tables give the identification of thousands of organic compounds divided into 17 classes. This includes boiling and melting points, crystal color, solvents and derivatives.

In the second part, the reader will find the miscibility of solvent pairs, the surface tension of various liquids, correction of boiling points, molecular depression of the freezing point, atomic weights and a few other data of importance.

An interesting compendium to have available and consult often.

Dr. Louis C. Barail
Barail Associates

HENDERSON'S DICTIONARY OF SCIENTIFIC TERMS

Seventh Edition by John H. Kenneth (D. Van Nostrand Company, N. Y., 595 pp., $12.50)

This seventh edition of a well known classic in its field has been considerably enlarged. It is stated that 1750 new terms have been added, bringing the total of listings to 15,600.

They cover eight of the fundamental fields of science, from Anatomy to Zoology. Each word is given its pronunciation, etymology, definition and any explanation needed to make the word fully understood and easy to remember, therefore this book is better than a mere dictionary. In the first pages, there are useful tables of equivalents and sound symbols. A very valuable book to scientists and perusers of textbooks.

Dr. Louis C. Barail
Barail Associates

TECHNICAL MEETINGS CALENDAR

1961 REGIONAL TECHNICAL CONFERENCES (RETEC)

June 14—Plastics in Packaging—Sheraton Mount Royal Hotel, Montreal, Quebec, Canada. Chairman: Ralph Noble, c/o Canadian Industries, Ltd., P.O. Box 10, Montreal, Quebec, Canada.

September 12—Plastics for Tooling sponsored by Central Indiana Section, Hotel Severin, Indianapolis, Ind. Chairman: Eugene C. Quear, c/o Delco-Remy Division, General Motors Corp., 2401 Columbus Ave., Anderson, Ind.

October 5—Plastics Foams sponsored by Buffalo Section. Section President: William Dunmyer, c/o The Carborundum Co., Building 71-1, Buffalo Ave., Niagara Falls, N. Y.

October 25—Plastics in Major Household Appliances sponsored by Kentuckiana Section, Monogram Hall, Appliance Park, Louisville, Ky, Chairman: Ray E. Eshenaur, c/o General Electric Company, AP-5-249, Appliance Park, Louisville, Ky.

November 2-3—Plastics in Packaging and SPE Southwestern Packaging Exhibition on November 1, 2, 3. RETEC sponsored by North Texas Section and Exhibition by Section with cooperation of Southwestern Division Chapter, Society of Packaging and Handling Engineers, Sheraton-Dallas Hotel, Dallas, Tex. Chairman: Peter W. Kent, 3637 Mid Pines Drive, Dallas 29, Texas.

November 15—Vinyl Plastics in the Household sponsored by New York Section with cooperation of Vinyl Plastics PAG, Statler Hilton Hotel, New York, N.Y. Chairman: Saul Gobstein, c/o Ferro Chemical Co., Box 607, Emerson, N. J.

December 1—Plastics Screw Injection Molding sponsored by Cleveland Section, Cleveland Engineering Society Building, Cleveland, Ohio. Chairman: Edward J. Haskins, c/o Injection Molders Supply Co., 17601 South Miles Road, Cleveland 28, Ohio.

Offers of papers for presentation at these Regional Technical Conferences are invited. Please address offers to RETEC Chairman or Section President.

ANNUAL TECHNICAL CONFERENCES (ANTEC)

January 30-February 2, 1962—18th ANTEC, Penn-Sheraton Hotel, Pittsburgh, Pa. Sponsored by Pittsburgh Section. General Chairman: John E. Parks, H.P.M. Division, Koehring Co., 512 Empire Building, Pittsburgh 22, Pa.

January 22-25, 1963—19th ANTEC, Ambassador Hotel, Los Angeles, California. Sponsored by Southern California Section. General Chairman: A. R. Tucker, Jr., c/o Dow Chemical Co., 900 Wilshire Blvd., Los Angeles 17, Calif.

January 28-31, 1964—20th ANTEC, Chalfonte-Haddon Hall, Atlantic City, N. J. Sponsored by Philadelphia Section. For information write Executive Secretary Thomas A. Bissell, Society of Plastics Engineers, Inc.

January 18-22, 1965—21st ANTEC, Boston, Mass. Sponsored by Eastern New England Section. For information write Executive Secretary Thomas A. Bissell, Society of Plastics Engineers, Inc.

INTERNATIONAL PLASTICS SHOW

June 21-July 1—International Plastics Exhibition and Convention, Olympia, London, England, Organized by **British Plastics.** Address inquiries to: Interplas '61, Dorset House, Stanford St., London S. E. 1, England.

POLYMER SYMPOSIUM

July 27-August 1, 1961, International Symposium on Macromolecular Chemistry, Montreal, Canada. Address inquiries to: The Organizing Committee International Symposium on Macromolecular Chemistry, P.O. Box 816, Sarnia, Ontario, Canada.

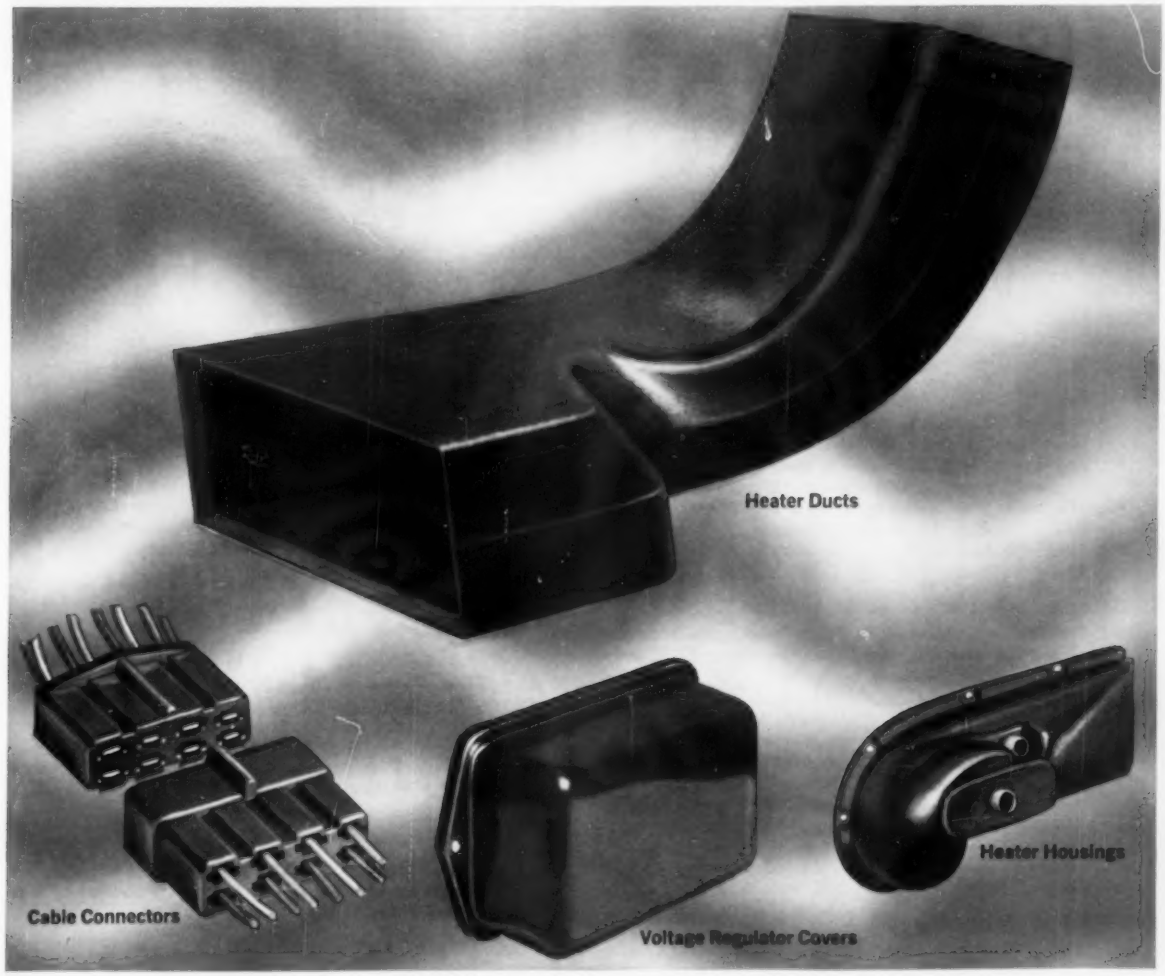
PLASTICS EXHIBITION

June 21-July 1, 1961, Sixth International Plastics Exhibition, organized for British Plastics and International Plastics Engineering by Iliffe Exhibitions Ltd., with the cooperation of the British Plastics Federation. The exhibition will be held in conjunction with the Interplas '61, Olympia, London.

MIT COURSE

The Massachusetts Institute of Technology announces an intensive course on Adhesive Joints to be given on June 26 to June 30, 1961. Ten lectures and discussion periods, about 3 hours each, are scheduled. The lecturers will include A. G. H. Dietz, F. J. McGarry and J. J. Bikerman from M.I.T., A. A. Marra, University of Michigan, N. J. De Lollis, Sandia Corp., and C. Dahlquist, J. L. Lubkin, and J. F. Murphy from industry. Application blanks should be requested from the Office of Summer Session, M.I.T., Cambridge 39, Mass.

What's News in Plastics...



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Yours with new Escon® 125 molding grade polypropylene!

Automotive applications are a "natural" for new Escon 125 polypropylene. This outstanding new grade is designed especially to maximize performance for long periods at high temperatures. Exceptional performance is achieved through a special LTHA (Long Term Heat Aging) stabilization system developed by Enjay research affiliates.

Escon 125 offers oxidative stability that, in carefully conducted laboratory tests against other commercially available grades of polypropylene designed for this type of service, outperformed all others tested. Specimens of Escon 125 withstood almost three months of oxidative aging at 300°F; specimens exposed to 250°F have shown no signs of failure after seven months. Melt index is 5.5 at 230°C. No changes are required in equipment, processing conditions or coloring techniques from those used with general purpose molding grades. For test samples and typical properties of new Escon 125, write to Enjay, 15 W. 51st St., New York 19, N.Y.

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SPE Publications For Sale

Annual Technical Conference Preprint Books

1. **17th ANTEC Preprint Book**—Volume VII, 1961, Washington, 100 papers. $7.50 members; $12.50 non-members.
2. **16th ANTEC Preprint Book**—Volume VI, 1960, Chicago, 83 papers. $7.50 members; $12.50 Non-members.

1960 Regional Technical Conference Preprint Books

3. **Plastics in Business Machines**—Binghamton Section, 8 papers, $2.50 members, $3.75 non-members.
4. **Plastics vs. Corrosion**—Golden Gate Section, 10 papers, $3.00 members, $4.50 non-members.
5. **Automation in Injection and Compression Molding**—Ontario Section, 8 papers, $2.50 members, $3.75 non-members.
6. **Plastics in the Petroleum and Chemical Industries**—North Texas Section, 8 papers, 63 pages, $2.50 members, $3.75 non-members.

1961 Regional Technical Conference Preprint Books

7. **Plastics Finishing Seminar**—Southern California Section, $2.00 members, $3.00 non-members.
8. **Plastics—A New Dimension in Building**—Western New England Section, $1.00 members, $1.50 non-members.
9. **Plastics in the Automotive Industry**—Detroit Section, $2.00 members, $3.00 non-members.
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15. **Vol. I—Quality Control for Plastics Engineers**—Lawrence M. Debing Ed., Reinhold Publishing Company 1957, 140 pages, $3.98, members; $4.95, non-members.
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. . . to guide you in selecting or developing the best plasticizing system for your product, your process, or your plant.

Monsanto's Plasticizer Council staff aggregates more than 250 years of experience in the technology of plasticizing. They bring to bear a fully equipped special laboratory for complete, competent guidance for our customers.

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1. **17th ANTEC Preprint Book**—Volume VII, 1961, Washington, 100 papers. $7.50 members; $12.50 non-members.
2. **16th ANTEC Preprint Book**—Volume VI, 1960, Chicago, 83 papers. $7.50 members; $12.50 Non-members.

1960 Regional Technical Conference Preprint Books

3. **Plastics in Business Machines**—Binghamton Section, 8 papers, $2.50 members, $3.75 non-members.
4. **Plastics vs. Corrosion**—Golden Gate Section, 10 papers, $3.00 members, $4.50 non-members.
5. **Automation in Injection and Compression Molding**—Ontario Section, 8 papers, $2.50 members, $3.75 non-members.
6. **Plastics in the Petroleum and Chemical Industries**—North Texas Section, 8 papers, 63 pages, $2.50 members, $3.75 non-members.

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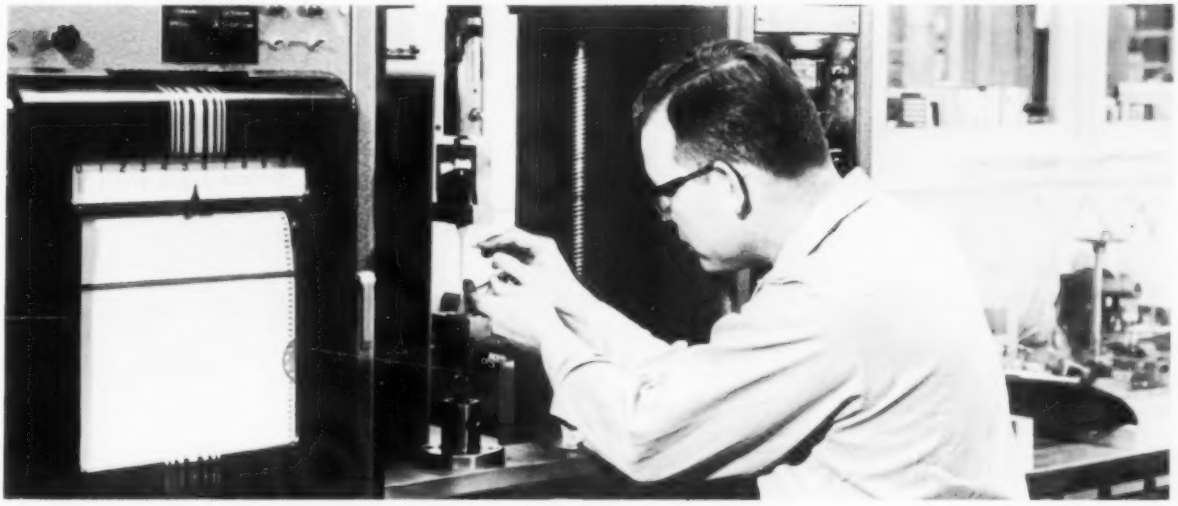

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SAVE ON MATERIALS HANDLING

Bulk-storage tanks installed at your plant can greatly reduce your materials-handling expenses: *lower labor costs and virtually no material spillage.* Monsanto can help you design your bulk-storage facilities and offer suggestions on their successful operation.

SAVE BY MIXED SHIPMENTS

Bulk or mixed-carload shipment prices average 10% below LTL or LCL costs. Two or three plasticizers, shipped in compartmented tank trucks or tank cars, are each billed at the tank truck or tank car rate. Any combination of drummed plasticizers may be shipped at the full truck or carload rate.

FAST DELIVERY

Your orders receive our prompt attention, *and we always strive to meet your delivery requirements.*

SUPPLIES ARE NEAR

Monsanto can ship tank trucks, tank cars, or carloads of most plasticizers from shipping points strategically located near every major plastics-manufacturing point. Producing plants at East St. Louis, Ill.; St. Louis, Mo.; Everett, Mass.; Long Beach, Calif.; and Anniston, Ala. Additional bulk storage at Akron, Ohio; Greensboro, N. C.; Houston, Texas; Miami, Florida; and Perth Amboy, N. J. Also 14 more warehouses blanket the nation for fast-delivery shipments.

CHEMICAL MATERIALS CATALOG, *page 432, gives technical and shipping information on forty Monsanto Plasticizers.*

How SANTICIZER® 409 gives vinyl products high-priced properties at the lowest cost of any premium polymeric plasticizer

PERFORMANCE: SANTICIZER 409 *stays put.* Its compatibility-stability is superior, under highly humid conditions, particularly when formulated with heat-stabilizing epoxy plasticizers. SANTICIZER 409 stubbornly resists migration to polystyrene—and to both natural and synthetic rubbers—as well as extraction by solvents. Stability to light and heat is exceptional. There's hardly a trace of odor or color.

PROCESSING: The good solvating action of SANTICIZER 409 can boost your output, too. Promotes fast fusion and extrusion. Helps prevent "fisheyes," roughness, and pinholes.

PRICE: SANTICIZER 409—*at 4¢ to 6¢ per lb. LESS than other premium-quality polymerics*—imparts top-quality performance to many kinds of vinyl products.

PROOF: Try it . . ."on paper," in the laboratory, in the plant. Compare SANTICIZER 409 with *any* other polymeric plasticizer (price, properties, stability, ease of processing). You will see that SANTICIZER 409 gives *more profit per unit volume of vinyl compound.*

FACTS: Technical Bulletin PL-409 gives complete performance data—including specific details on how SANTICIZER 409 can help you make:

- **105° wire compound with exceptional electrical properties and retention of elongation.**
- **permanent, adhesive-backed film.**
- **migration-resistant, low-odor refrigerator gasketing.**

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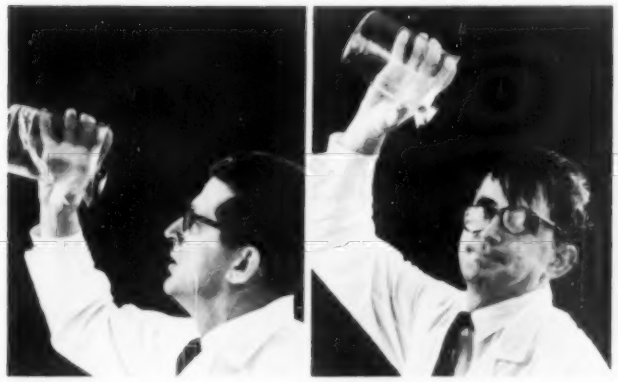
How MOD-EPOX® liquefies viscous epoxy resins and "liquidates" some of the cost



PERFORMANCE: Reactive MOD-EPOX reduces epoxy resin viscosity as much as 75%, combines *chemically* in the curing to become part of the resin. This means you can use more filler, yet have faster flow, less entrapped air, fewer rejected finished parts. And final properties are actually *improved:*

FLEXURAL STRENGTH OF 4-PLY GLASS FIBER-EPOXY LAMINATES (ASTM D638)

FORMULATION:	Control	with MOD-EPOX
MOD-EPOX	—	25
liquid epoxy resin	100	100
diethylenetriamine	12	8
magnesium oxide (fluffy)	—	0.25
FLEXURAL STRENGTH:	**psi**	**psi**
original	42,400	48,400
ketone—40 hrs. @ room temp.	42,400	47,700
water—40 hrs. @ 100°C.	29,400	37,600
10% caustic—27 hrs. @ 100°C.	8,500	9,200

Epoxy resins modified with MOD-EPOX for better flow and lower cost show better dimensional stability—lower power factor—equivalent hardness—and higher adhesive strength (*shear bond strength of a standard epoxy adhesive increases more than 50%, steel-to-steel*).

ECONOMY: NOW . . . MOD-EPOX at 36¢/lb.* costs less than any grade or brand of epoxy resin, 50-75% less than most other modifiers . . . AND reduces the curing-agent requirements to about ⅔ of usual amounts.

FACTS: Tęchnical Bulletin PL-313 gives complete performance data—including specific details on how MOD-EPOX can help you make:

- **easy-handling electronic potting compounds.**
- **low-cost auto-body-solder formulations.**
- **high-strength casting and encapsulating compounds.**
- **tenacious adhesives for metals and glass.**

*T/L and C/L, F. O. B. Monsanto, Illinois

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☐ **Technical Bulletin PL-409** on SANTICIZER® 409 . . . more-for-the-money polymeric plasticizer

☐ **Technical Bulletin PL-313** on Monsanto MOD-EPOX® . . . key to better, lower-cost epoxy resins

☐ **Technical Bulletin PL-160** on SANTICIZER® 160 . . . quick-fusing, stain-resisting phthalate ester

☐ **Technical Bulletin PL-306** . . . tells how Monsanto AROCLOR® Plasticizers impart high resistance to flame and chemicals at low, low cost

☐ **Technical Bulletin PL-327** . . . tells how to formulate better protective coatings with Monsanto plasticizers

☐ **Technical Bulletin PL-314** . . . tells how to save time, labor, and material expense in the bulk handling and storage of Monsanto plasticizers

How SANTICIZER® 160 speeds processing and cuts costs of nonstaining PVC film and sheeting

PERFORMANCE: No other plasticizer can make film, sheeting, and floor covering so *STAIN-SAFE*—virtually impervious to asphalt, tar, grease, mustard, catsup, coffee, and other stainmakers. SANTICIZER 160 (butyl benzyl phthalate) also imparts toughness, high gloss, *and outstanding tear strength and dimensional stability.*

PROCESSING: Quick-fusing SANTICIZER 160 speeds Banbury mixing, milling, and calendering—*at lower processing temperatures.*

ECONOMY: SANTICIZER 160 is one of the lowest-priced primary plasticizers for vinyls. With its high tolerance for fillers and its high compatibility—*150 PHR for poly(vinyl chloride), 75 PHR for poly(vinyl acetate)*—it offers compounders savings on material, savings on formulation.

"TAILORED" BLENDS: In large-volume applications, when several plasticizers are used together in a fixed ratio for optimum performance, Monsanto can usually *custom blend* them to your specifications . . . to reduce your storage-facility requirements; eliminate mixing error or variation; and reduce inventory requirements, ordering costs, and production expense.

FACTS: Technical Bulletin PL-160 gives complete performance data—including specific details on how SANTICIZER 160 *also* can help you make:

- **lower-cure-temperature plastisols and organosols.**
- **high-gloss, water-resistant lacquers.**
- **economical vinyl chloride-vinyl acetate emulsions.**

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SECTION NEWS

Philadelphia

Philadelphia Plant Visit

GEORGE R. De HOFF
(E. I. du Pont de Nemours & Co., Inc.)

On April 25 the Philadelphia Section was privileged to tour the Firestone Tire Plant at Pottstown, Pennsylvania. About 220 members and guests enjoyed dinner in the plant cafeteria after which Mr. E. H. Hunnicutt, General Plant Manager, welcomed the group to Firestone. Mr. John Griffith, Technical Manager, Chemicals, described the areas to be toured and the safety requirements. Mr. D. E. Story, Director of Public Relations told the group of the history of the Firestone Plant in Pottstown and presented various statistics on their operations. Then about twenty Firestone employees patiently guided the groups through the plant, explaining the tire manufacturing operations from the processing of the various rubbers through the curing and inspection of the finished tire.

The large attendance at this meeting reflects the excellent job the program committees have done over the past years in arranging excellent tours of the plastics and related plants.

Connecticut

Relationship of Physical Properties to Structure of Thermoset Resins

KENNETH G. CLARKE
(E. I. du Pont de Nemours & Co., Inc.)

The guest speaker at the April meeting was Dr. Ernest H. Wood of the Chemical Research & Development Laboratory, American Machine & Foundry Co., Springdale, Connecticut, who discussed the relationship of physical properties to the structure of thermoset resins.

Dr. Wood contrasted the characterization of thermoplastics with thermosets, the latter being considerably more difficult and empirical because of the chemical reactions occurring during cure. In spite of these difficulties, great strides have been made in characterization research on both polyesters and phenolic type of thermoset resins.

The chemical composition, chemical isomerism and least chain length were discussed as they affect physical properties of the molded parts.

Dr. Wood emphasized the importance of these useful tools in estimating property changes, so that a few of the many variables involved in product improvement research could be isolated and eliminated.

Mr. Harlan Fisher, Watertown Manufacturing Company, Watertown, Connecticut, President of the Chapter, announced that the May meeting of the Chapter will be held at the Hotel Barnum in Bridgeport. The guest speaker will be Mr. F. J. Donohue of Monsanto Chemical Company, whose topic will be "Granulated Wood Molding".

Rochester

Extruder in Operation

J. T. BENT
(Eastman Chemical Products, Inc.)

On Monday, April 10, the Rochester Section had the most heavily attended meeting in its history. Ninety-six members and guests sat down to dinner, and an additional fifteen or twenty members attended the meeting after dinner.

The reasons for the extraordinary interest in this meeting, which attracted members from other Sections, were both the well-known capabilities of our speakers, as well as what is believed to be an SPE all-time first! The actual setting up of an extruder within the Section meeting place, and the blowing of lay-flat tubing both in natural as well as in color, by using color-concentrates.

Mr. Herbert O. Corbett, Chief Extrusion Technologist for the Kordite Company of Macedon discussed the various commonly used methods of film production—both by blowing and chill-roll casting. He pointed out that watching the actual blowing of polyethylene film would serve to answer the many questions his audience had.

Mr. George Prall of the Kordite Company spoke on profile extrusion, with special emphasis on the manufacture of extrusion dies. His very well illustrated talk was of great practical value, and our membership obviously appreciated the compliment paid to it by this well-known extrusion expert.

Our Section was honored by the presence of Mr. James Lampman, SPE Vice President—Engineering, who delivered a well-chosen and enthusiastic message on SPE affairs.

St. Louis

Two-Fold Program

RICHARD H. KOEHRMANN
(International Shoe Co.)

On April 17, forty-seven members and guests heard Mr. John M. Berutich, 1961 S.P.E. National Treasurer talk on "Progress and Goals of the International Society for 1961" at the Holiday Inn, South.

For the technical discussion, Mr. Gale G. King and Mr. Robert J. Crook of King Chemical Co. discussed the uses and method of application of rigid urethane foam. To illustrate the action of the materials several foaming demonstrations were conducted.

The speaker for the May meeting will be Mr. S. R. Melvin, Monsanto Chemical Co., Plastics Division, Springfield, Mass.

Ontario

Makrolon Polycarbonate

HAROLD A. SHURE
(Naugatuck Chemicals)

Eighty-seven people attended the meeting on April 13 and saw a colour movie on polycarbonate resin. It was introduced by Mr. E. S. McDougall of The McArthur Chemical Co. Ltd., who stressed that polycarbonates were unique in their combination of outstanding properties. In addition to exceptionally high impact strength, these new resins possess good electrical properties, excellent dimensional stability and heat distortion range.

The movie was highlighted by some fascinating shots of the various types of injection molding machines, extruders, blow molding and vacuum-forming equipment. The processing of Makrolon and some of the more important applications were shown in this fine technical film.

Mr. McDougall concluded his presentation by illustrating the properties of this new exciting polymer by means of a variety of samples.

Newark

Screw Plasticizing in Injection Molding Machines

R. E. CHRISTENSEN
(Union Carbide Plastics Co.)

The Newark Section met on April 12th at the Military Park Hotel in Newark. The annual golf outing was announced for June 14th at the Wayne

Country Club, with many activities, in addition to golf, and prizes promised by George Reed, Outing Chairman.

The speaker for the evening was Mr. Jack G. Fuller, Sales Manager of Ankerwerk International, Santa Ana, California. Mr. Fuller discussed the development of screw plasticizing in injection molding machines and compared this relatively new process to the conventional ram torpedo plasticizing in injection molding machines. This new development originated in Europe because of the use of rigid vinyl there and the need for better plasticizing. Conventional plunger machines have the disadvantages of high pressure loss, a heat transfer problem and poor homogeneity. The development of preplasticizing units and the Reed Jet-Flo machine was a partial step in the right direction. The advantages of the Ankewerk screw-injection molding machine are: a more homogeneous melt, lower pressure operation, lower melt viscosity, easier color change, reduced strain in molded parts.

Baltimore-Washington

Polyolefin Blends and Copolymers

S. P. PROSEN
(U. S. Naval Ordnance Laboratory)

On April 11, the Baltimore-Washington Section met at the Dodge House in Washington, D. C. The meeting, with 21 persons attending, was chaired by Dr. Stromberg of the Bureau of Standards. He announced the results of the election for members of the Board of Directors, elected for three-year terms, were: Porter Erickson, Naval Ordnance Laboratory; John Alfers, Bureau of Ships; and Karl Plitt, Diamond Ordnance Fuze Laboratory. Elected for one year to fill a vacancy was Arthur Dellheim of Adell Plastics, Inc.

The feature of the evening was a talk given by A. A. Haas of W. R. Grace on "Polyolefin Blends and Copolymers." Stressed in the talk were reasons for blending and copolymerizing and their effects on flow and ultimate properties. The importance of molecular weight distribution, as well as density and melt index on flow, was discussed.

Mr. Haas suggested that blends of polyethylene are offered by the resin manufacturer, the reprocessor, and the fabricator, and that blending done by the fabricator caused the most trouble. The fabricator must do more than dry blend by tumbling low and high density polyethylenes to get good properties. He must mix in an extruder with at least a 24 to 1 length to diameter ratio or mix in a Banbury. In fact, the fabricator shouldn't arbitrarily select two materials for blending, because the properties of the blend would not be linearly additive.

Discussed also were blends of polyethylene and Vistenex rubber and polypropylene and Vistenex. The reasons for copolymerizing to overcome stress-cracking were discussed and some examples given.

Miami Valley

Opportunities Unlimited in Plastics Engineering Students' Meeting

ROGER A. HOUSTON
(Recto Molded Products, Inc.)

Miami Valley's most inspiring and enthusiastic meeting of all time was held on March 3rd at the Engineering Society of Cincinnati's luxurious headquarters. Among the 123 members and guests were 42 chemical and engineering majors, chosen by their instructors, who accompanied them, from the Univ. of Cincinnati, Miami Univ., Xavier Univ., and the University of Dayton.

The dinner was followed by a series of meaty talks aimed directly at the interests of the guest students. The choice of speakers had been excellent and the interest was intense.

Mr. E. Burrell, Manager Resins Development Laboratory for the Inter-Chemical Corp., and a lecturer at Xavier University, keynoted the program with a talk on "Plastics Technology and its Implications".

Dr. P. W. Crane, Vice-president and Director of Research for the Cincinnati Milling Machine Co., talked on "Opportunities in Research and Development".

Mr. J. R. Twining, Manufacturing Superintendent for Monsanto Chemical Corp., stressed production and work and showed the "Opportunities in Production and Engineering".

Mr. R. H. Reiger, Technical Representative for the Union Carbide Plastics Co., developed interest in "Opportunities in Sales", giving a technical background slant.

Mr. C. J. Hannon, Treasurer of the Formica Corp., spoke on "Opportunities in Organization".

These talks were followed by a panel discussion which developed considerable interest and gave an insight into the thinking processes of students in approaching decisions for their future.

Section Dinner Meeting

The April 6 meeting was held in the new Empire Room of the Golden Lamb Hotel in Lebanon, Ohio. The Golden Lamb is a famous old hostelry of the stage coach days.

Following a traditional dinner the 45 attending members were addressed by Jack L. Shafer, Marketing manager of the Dapon Department of Food Machinery & Chemical Corp., of New York.

He gave a most delightful and entertaining talk concerning the possibilities of using Dapon Resins and Diallyl Phthalate Monomers and their role in our own types of applications.

Golden Gate

Screw Plasticizing Injection Presses

Mike Rabin
(Transparent Products Corp.)

On February 24th, 1961, 35 members of the Golden Gate Section, and guests, met for the regular monthly meeting at the International Inn where Mr. Brant Newson, President, introduced the guest speaker, Mr. Jack G. Fuller who is Sales Manager, of Krauss-Maffei International, Ankerwerk International.

Mr. Fuller spoke about the general acceptance in Europe of the German-manufactured reciprocating screw plasticizing injection molding machine and of its potential in this country.

Using slides in illustration, he noted that several of the advantages over the use of conventional plunger-type presses are (1) greater melt capacities, (2) more homogeneous melts, (3) faster speeds, (4) ease in processing color changes, (5) more stress-free molded parts and (6) lower pressure requirements.

Mr. Fuller stated that the basic patents are held by Egan Company in this country. Today 90% of injection presses manufactured in Europe are the screw plasticizing type. Several domestic press manufacturers have taken out Egan licenses.

Your Section News is of interest to all members, as they may wish to follow up some of the news items. Rapid and accurate reporting of your section's technical meetings will be mutually beneficial. Remember deadline date for each issue is the first of the preceding month.

ABOUT MEMBERS

George H. Hunt III moves up to sales manager of the new halogenated plastic products plant of Tube Turns Plastics, Inc., in Dallas, Texas. Mr. Hunt is a 1956 physics graduate of the University of Louisville and was formerly manager of TTP's technical department.

Dow Corning Corp. has named **Robert E. Vidal** manager of the Greensboro Division of Dow Corning in line with the company's desire to set up the operations there under a single overall executive. A graduate of the Case Institute of Technology, Mr. Vidal, who has been with Dow since 1951, will administer the textile emulsion plant, Silicone Specialties Manufacturing and Sales and New Product Engineering Laboratories.

Harry Stephenson is now regional sales manager for Ren Plastics, Inc. covering the southwest. A journeyman tool and die maker, Mr. Stephenson attended Detroit College of Applied Science, and has been associated in engineering and sales with several leading plastics firms.

Michael Zarebski has been named general manager of Reichhold Quimica de Mexica, S. A., according to an announcement by Henry H. Reichhold, President of Reichhold Chemicals, Inc. Mr. Zarebski is a graduate chemical and metallurgical engineer and has been associated with the firm's Canadian operation.

M. Elber Latham has been designated division manager, Youngstown, Ohio Division of Swedlow, Inc., responsible for all manufacturing, technical and sales functions. He is a graduate of Nebraska Wesleyan University with a B.S. degree in Mathematics and a graduate student of the University of Nebraska with a major in Physical Chemistry.

Dr. Ray L. Hauser has recently founded the Hauser Research and Engineering Co. to provide consulting and research services related to non-metallic materials. He is a graduate of Illinois, Yale and Colorado Universities and has been associated most recently with the Martin Co., Denver. His specialty will be in plastics for cryogenic temperatures. Dr. Hauser is SPE Councilman for the Rocky Mountain Section and 1961 Chairman of the Sections Committee.

Ludlow Papers and Ludlow Plastics Division of Ludlow Corp., Needham Heights, Mass., have moved their New York offices to larger quarters located at 12 E. 41 St., N. Y. 17, N. Y. **John J. Keville,** director of marketing, plastics, is headquartered there.

Dr. Herman F. Mark has been elected a member of the National Academy of Science. Dr. Mark is a member of SPE's Publications Committee and is Director of the Polymer Research Institute, Brooklyn Polytechnic Institute.

Western New England

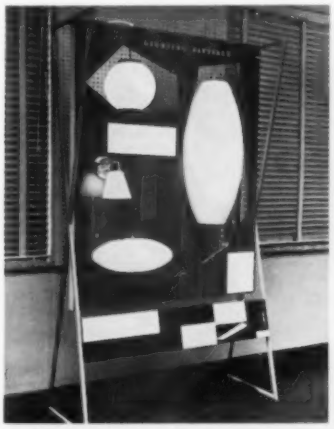
Western New England Section has successful RETEC

"Plastics—A New Dimension in Buildings" was the subject of an interesting SPE Regional Technical Conference (RETEC) sponsored by the Western New England Section in Springfield, Massachusetts April 20. This conference coincided with the first showing of a travelling exhibit demonstrating the application of plastics in building and was held in cooperation with the Plastics in Buildings, Professional Activity Group (PAG).

Subjects discussed were, plastics in building exteriors, importance of structural and dimensional stability of plastic materials, resistance to weathering, thermal insulation and plastics in lighting applications. The technical exhibit included plastic materials and designed and integrated products for constructional, decorative and interior uses.

The conference which was attended by 255 persons had Robert W. Sherman of Union Carbide Plastics Co. as General Chairman. The two luncheon speakers were Frank W. Reynolds, SPE President, of IBM Corporation and Philip George of George Nelson Co., who spoke on the respective topics, The Challenge of the Future and Interior Designing with Plastics.

Robert W. Sherman, Union Carbide Plastics Co., General Chairman of the RETEC.



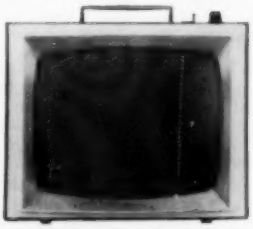
Plastic Lighting Fixtures, a typical example of the thirty display units.

James S. Lunn, Lunn Laminates, who spoke on Structural Aspects of Plastics.

Performance-proved by these TV leaders!

BAKELITE®

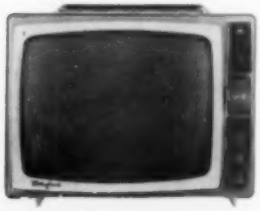
ADMIRAL parts molded of TMD 5161 by Superior Plastics, Inc.; J. P. Gits Molding Corp.



GENERAL ELECTRIC parts molded of TMD 5161 by Buffalo Molded Products; Plastic Inlays, Inc.; Presque Isle Plastics, Inc.

PHILCO parts molded of TMD 5161 by Champion Molded Plastics, Inc.; Buffalo Molded Products; St. Regis Paper Co.

SYLVANIA parts molded of TMD 5161 by Buffalo Molded Products; Presque Isle Plastics Inc.; Plastic Inlays, Inc.; St. Regis Paper Co.



WESTINGHOUSE parts molded of TMD 5161 by Plastic-Ware, Inc.; St. Regis Paper Co.

WARWICK (Sears-Roebuck) parts molded of TMD 5161 by Sinko Mfg. Co.; General American Transportation Corp.; Amos Molded Plastics; Plastic-Ware, Inc.

HIGH-IMPACT, HEAT-RESISTANT STYRENE TMD-5161

It could be the answer to your parts problems!

If you require heat resistance in a high-impact styrene . . . good retention of impact strength . . . high gloss . . . useable toughness at low temperatures, BAKELITE TMD 5161 has them all! It possesses the good molding latitude and flow properties of lower impact styrene grades.

General acceptance by leading TV manufacturers for assembly-line production of large intricate parts is proof of its outstanding performance characteristics.

Versatile BAKELITE TMD 5161 is also used for housewares, battery cases, and industrial applications where a combination of heat resistance and high-impact strength is desired.

Want more information? Write Dept. IS-132F, Union Carbide Plastics Company, Division of Union Carbide Corporation, 270 Park Ave., New York 17, N. Y. *In Canada:* Union Carbide Canada Limited, Toronto 12.

UNION CARBIDE

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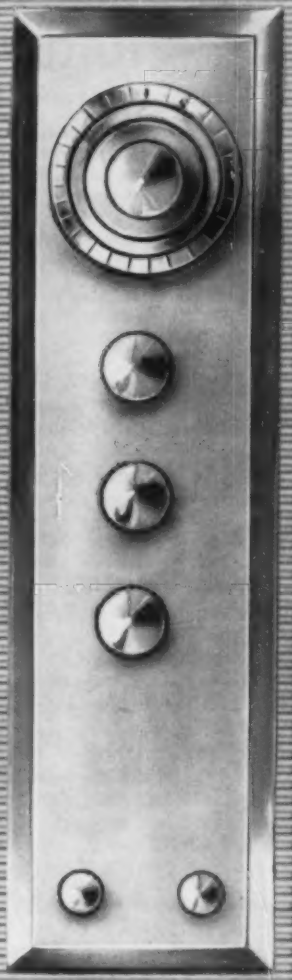

PLASTICS AROUND THE WORLD

This month's column has been made possible through the contribution of these abstracters:
Gerhard Kracht (Plaste and Kautschuk and Kunststoffe)
Alexander Baczewski (L'officiel des Matières plastiques and Pensez Plastiques)
Hans Mayer (Industries des Plastiques Modernes)
Leonard Buchoff (Materials in Design Engineering)
Alfred Alk (Materie Plastiche)

Germany

PLASTE UND KAUTSCHUK

FEBRUARY 1961

Attack on Polyvinyl Acetate Dispersions by Moulds and its Suppression—pp 74-76

Even without the addition of foreign substances, PVA dispersions are attacked by moulds when stored for some time. Although pure films show no signs of fungous growth, they do not resist it when used as coatings for layers heavily disposed to mould attack. Trubutyl tin hydroxide, chloracetic amide and sodium silicofluoride are useful for the suppression of fungous growth. (Two tables.)

Modification of Mechanical Properties of Cord by Influences of Ionizing Radiation—pp 66-69

In the presence of air, ionizing radiation reduces the strength and elongation of all types of cord investigated by the authors. The lowest resistance was shown by polyamide cords, the highest by "Terylene" cords. Gamma rays of the Co^{60} radioisotope were used for the radiation. Illustrated with eight figures.

MARCH 1961

Plasticizers for Polyvinyl Chloride. Properties of Linear Tetraesters—pp 125-127

The study of saturated linear tetraesters with regard to their suitability as PVC plasticizers included the evaluation of the solubility, stability of the system, effect of the plasticizer volatility and cold resistance. The properties of tetraesters depend on their structure. Optimum properties are obtained by a large distance between the polar groups and by the termination of the chain by four carbon atoms containing linear aliphatic compounds. There are three figures and four tables.

Rubber Abrasion—pp 128-131

The different methods for determining the abrasive resistance of rubber are hardly comparable. The author describes all test methods being used today as well as the specific equipment requirements, using four tables and one figure in the article.

KUNSTSTOFFE

JANUARY 1961

UV Absorbents as Synthetic Resin Stabilizers—pp 13-17

Possibilities and limits of effective light stabilization of plastic materials are pointed out. The various commercial UV absorbers on the market today are classified and examples of their applications are given. Seven figures and four tables are used to illustrate the text.

FEBRUARY 1961

X-Ray and Infra-Red Spectroscopic Methods for Determining the Crystallinity of Polyethylene—pp 69-74

The authors describe the evaluation of x-ray and infra-red spectroscopic results obtained in experiments to determine the crystallinity of polyethylene. The crystallinity values obtained by the two methods differ from each other only very slightly. There is a linear relationship between the crystallinity and the specific volume of polyethylene. It appears that both methods work equally well, registering both the structurally different crystallinity components and the non-crystalline ones in polyethylene. Seven figures and one table are included.

Welding of Polypropylene Sheet, Tube and Rods—pp 104-105

The introduction of polypropylene has enlarged the market of semi-finished products. Polypropylene in sheet, rod, or tube form possesses a higher degree of heat resistance than polyethylene or PVC. The good heat resistance of polypropylene makes the production of various instruments possible. The article also describes a welding-technique for polypropylene. There are four figures shown.

France

L'OFFICIEL DES MATIERES PLASTIQUES

MARCH 1961

Non-supported Films—pp 215-217

A simple new process has been patented in Germany for the manufacture of rough textured extruded poly(vinylbutyral) films as used for the manufacture of safety glass. The desired roughness is obtained by adding water to the mass before extrusion.

Vinylchlorides—pp 221-223

First installment of a description of Central and East European progress in the field of synthesis is offered. Manufacture of acethylene and its catalytic hydrochlorination are described. Two drawings, six references.

Preheating of phenolic molding resins—pp 224-226

British made equipment makes it possible to cut molding cycles by 50%. Cost estimates (for France) are given.

Silicones and glass fibers—pp 239-253

This is an extensive report on the state of low pressure laminating in France by a leader in his field. Finishes, dielectric applications, structural laminations, non-adhesive conveyor belts and many more uses are mentioned.

Plastics in the building trades—pp 261-262

An annotated list of 60 (mainly French) patents is presented.

PENSEZ PLASTIQUES

JANUARY 1961

The plastification of poly(vinylchloride)—pp 5-8

Mainly a dissertation on the drawbacks of epoxydized oils, the author recommends them for their aid in stabilization and their low cost.

Semiorganic polymers—pp 9-13

The article encompasses the introduction of aluminum into silicones, rings containing boron or phosphorus and nitrogen and several polymers containing lead or titanium.

The transmission of gasses through plastic film—pp 19-24

A reprint from Materie Plastiche reviews methods for measuring

rates of gas transmission. An apparatus similar to the one suggested by ASTM D 1434-56T is described with eight illustrations and 17 references.

FEBRUARY 1961

Properties of Moplen pipes—pp 21-25

A reprint from Materie Plastiche covering the properties of isotactic polypropylene is presented.

INDUSTRIES DES PLASTIQUES MODERNES

MARCH 1961

The Basic Problem of Preparation of Test Specimens for Evaluation Tests

The evaluation of plastic materials with regard to the properties of molded specimens is often conducted by laboratory tests on molded test pieces not prepared under the same conditions. The mold design, pressure applied, heat, curing cycle and other important parts of the molding process are unknown. The results obtained in testing these parts do not truly cover the properties of the test material in general, but only the properties observed under the conditions of molding. Suggestions to set up standard rules for design of tools and molding techniques to achieve test results of a true and general nature are made.

The Inside Coating of a Metal Tank with Glass Polyester Laminates.

The polyester-fiberglass coating of the inside of a metal tank is described. After cleaning the tank, a number of coatings of resin and fiberglass are applied, one on top of the other with a resin application forming the first and the last coating.

Coating of Metallic Parts with Acrylic Materials, Rilsan No. 11

Due to the availability of this material in a special granular size, satisfactory coatings have been obtained by the use of either one of these two methods:

1) Spray gun application: the metal parts are preheated after having been thoroughly cleaned and the granules are sprayed by a gun through an open flame on to the parts.

2) The metal parts, again thoroughly cleaned, are preheated and dipped into a tank inside of which the granules are being kept in constant movement by means of air blasts.

It is claimed that both methods result in complete coverage, good adhesion and good appearance.

USA

MATERIALS IN DESIGN ENGINEERING

JANUARY 1961

Picking a Coating to Resist Water Corrosion—pp 71-75

Advantages and disadvantages are presented for coal tar enamel, coal tar epoxy, epoxy, vinyl, chlorinated rubber, and phenolic tung oil as coatings in submerged applications.

Do You Need Filled TFE?—pp 81-83

The use of filled TFE Teflon in tape is described. The filled TFE provides better wear resistance, reduced deformation under load, and lower thermal expansion than the unfilled.

Italy

MATERIE PLASTICHE

MARCH 1961

Plastics in Irrigation Part II—pp 279-296

This part describes and discusses rigid PVC pipe and tubing. Tables and graphs are provided covering physical and chemical properties, dimensions and weights. Various joining methods are described and illustrated including some not employed in the U.S. Methods of irrigation are also illustrated.

The Results of Truck Cultivation in an Albenga Style Movable Greenhouse. G. Brandinelli—pp 301-309

Montivel polyester film was adopted for this experiment in movable plastic field protection. Posts and rafters were erected and upon these were placed panels of film on wooden frames. The film was applied to the frames with adhesive as detailed in the text. Planting was performed in the usual manner but 2 to 3 weeks earlier than normal. As the season progressed, the panels were removed and final cultivation and maturing took place without artificial aids or protection. Yields obtained were higher and much sooner than normal. Experimentation continues.

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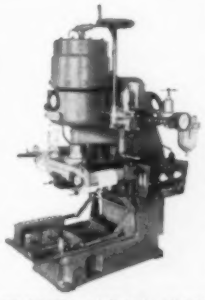
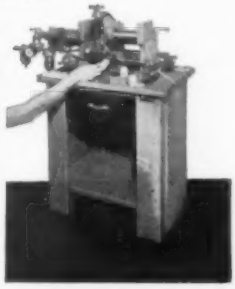
Hot Stamping Machines used with ACROLEAF® foil, actually "fuse" the plastic color pigment with the plastic product thereby making a permanent, sharply attractive mark or decoration.

WRITE FOR fully illustrated color folder illustrating, describing and showing products marked and the complete ACROLEAF® PROCESS. Ask for ACROLEAF® CATALOG No. 54HS.





ACROLEAF® MODEL 9AH

This is "the original" hot stamping machine for peripheral marking. Unequalled for fine work and fast operation, semi or fully automatic with electronic controls.

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"The Original Marking Specialists"

U.S.I. POLYETHYLENE NEWS

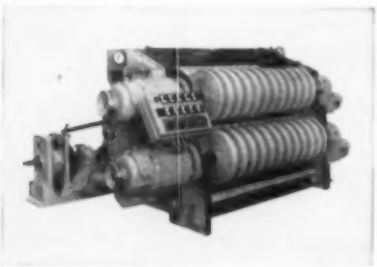
A series of advertisements for plastics and packaging executives by the makers of PETROTHENE® polyethylene resins

JUNE, 1961 — U. S. Industrial Chemicals Co., Division of National Distillers and Chemical Corporation — 99 Park Ave., N. Y. 16, N. Y.

Packaging Notes

Tamper-proof, re-sealable container for liquids, powders or pills features a unique, locked-in closure of polyethylene. A protruding knob can be "snapped off" easily with one hand—yet is completely tamper-proof before purchase and use since closure is a one-piece unit. To re-seal, user merely sets the now-separate tip into opening and presses it down until it locks in place.

High-speed slitting machine slits and rewinds polyethylene film, coated papers and other materials of uneven caliper at speeds up to 1700 ft. per min. Available in all sizes up to 64" web width for razor blade or shear cut.



New sealer-handle designed for use on polyethylene bags provides an air-tight waterproof seal, then locks to form a convenient carrying handle. Current applications include packaging fruit, produce, toys.

It's of simple, one-piece construction—just a strip of .060 inch polyethylene with a horizontal center slit and interlocking hooked ends. To apply, top of the filled bag is pulled through the slit, the sealer-handle rolled downward and the hooks joined. To open, process is reversed. Neither sealing nor re-opening damages bag.

This device, also reusable, will reportedly hold any weight the bag will support. Since two separate bags can share a common sealer-handle, it's ideal for tie-in merchandising.

Polyethylene sealer-handle attaches in 4 to 5 seconds, can be used over and over.

Magazines Now Mailed In Polyethylene Film

Tight, Handsome Machine-Wraps Protect Better, Cost Less

Hand insertion of magazines into envelopes may soon be a thing of the past. A Midwestern printer now packages publications for mailing at the rate of 1000 magazines per hour, twice the rate of the hand operation!

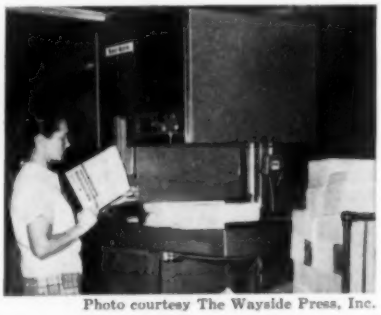


Photo courtesy The Wayside Press, Inc.

Publication is shown being packaged in polyethylene film. Magazines reach subscribers clean, fresh and undamaged.

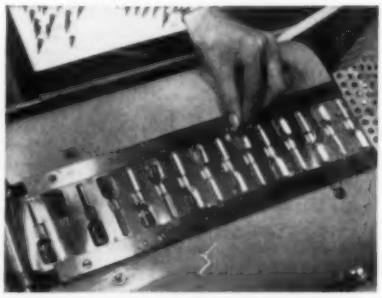
He uses rolls of 1.5-mil polyethylene film printed in two colors. A Model MA packaging machine forms bags around the magazines and heat-seals them tightly against moisture and dirt.

High Acceptance

The printer reports that after the first experimental mailing of 100,000 magazines, no complaints were received from either the Post Office or from subscribers. In fact, subscribers have written to the publishers expressing enthusiasm for the improved appearance of the mailed material and the better condition of the magazines on arrival. Front and back covers are clearly displayed through the transparent film.

The success of this printer with polyethylene-packaged magazines opens up a whole new field of possibilities for the mailing of printed matter. Improvements were achieved with no increase in overall costs. The advantages of mechanization, improved appearance, colorful package printing, and protection against soiling, rough handling, tearing and weather should not be overlooked by anybody who ships extensively through the mails.

Polyethylene Helps Package Hypodermic Needles



Polyethylene plays a multiple role in a new strip package developed in England for hypodermic syringe needles. The web materials used are polyethylene coated cellulose film and a laminate of .0035 mm aluminum foil and .0015 in. polyethylene film.

Novel automatic machines form shaped depressions in the foil web to receive the needles and, after these have been hand-inserted, complete the packs with the cellulose film cover and a polyethylene-to-polyethylene heat seal.

The finished strip is scored for easy tearing between each needle packet and cut after every twelfth. As a final step the needles are sterilized by permeating the package with ethylene oxide gas.

Polyethylene's toughness, resistance to bacteria and moisture-barrier properties also get into the act—keeping the needles sterile and ready for use almost indefinitely.

Did You Miss These?

Reprints of two recently published articles on polyethylene are currently available through U.S.I.:

1. "Poly Bread Wraps: Growth Continues," 4 pages, by William U. Funk, U.S.I. Sales Engineer.
2. "The Effect of Molecular Weight Distribution on the Flow Properties of Polyethylene," an 8-page technical report of experimental work conducted at U.S.I.'s Polymer Service Laboratories.

If you missed either or both of these timely articles, or would like extras for your file, copies can be obtained by writing Technical Literature Department, U. S. Industrial Chemicals Co., 99 Park Avenue, New York 16, N. Y.

IF YOU WOULD LIKE further information on any developments reported in U.S.I. Polyethylene News, U.S.I. will be glad to send you the names of the manufacturers. U.S.I. also invites you to send information on your new developments for possible inclusion in the News.

Address:
U.S.I. Polyethylene News, U.S. Industrial Chemicals Co., 99 Park Avenue, New York 16, New York.

So that you can get the information you want in the shortest possible time, we suggest you write directly to the company address listed at the end of each new product item.

New Materials and Equipment

MATERIALS AND APPLICATIONS

New Polypropylene Polymers

Three new polypropylene polymers, two meeting FDA regulations for food and drug applications, have been introduced. For extrusion applications, the new food grade polymers are 4011, and for injection molding uses, 4014. Another, a high flow injection molding polymer, Grade 1016, is designed for high speed multiple cavity molding situations when close shrinkage and warpage control of the molded part are desired. Write *Dept. SPE*, **AviSun Corp., 1345 Chestnut Street, Phila., 7, Pa.**

Aid to Vinyl Compounders

A new line of low viscosity monomeric plasticizers has been designed to help vinyl compounders meet recently revised automotive requirements, at a minimum cost. The new requirements demand absolute minimums in volatility in addition to excellent low temperature properties. Admex 752 and 655 join Admex 750 introduced last year. It is expected that more durable upholstery fabrics will be possible. For information, *Dept. SPE*, **Archer-Daniels-Midland, 700 Investors Building, Minneapolis 2, Minn.**

New Testing Equipment

A simple, quick, accurate process to test heat treatment of conventional and linear polyethylene has been devised. Consisting of two specially formulated spray lacquers in aerosol cans, one for conventional polyethylene, one for linear polyethylene, the method does not require the services of highly skilled personnel. Check with *Dept. SPE*, **The Avondale Co., 260 Happ Rd., Northfield, Ill.**

New Foam for Garment Interlining

Affording closer knit appearance and better drape, a new special formulation polyester urethane foam for garment interlinings has been developed. Good to look at, warm, yet light weight, it fulfills a need of the textile industry. Available in lengths to 450 yards and in widths from 36 to 77 inches, it can meet specifications and requirements unlimited! For information, *Dept. SPE*, **Nopco Chemical Co., Plastics Div., North Arlington, N.J.**

Polypropylene for Elevated Temperatures

Designed for superior performance for extended periods at elevated temperatures, a new Escon polypropylene grade is now available. Easily colored too, it is recommended for applications in which molded parts are subjected to repeated, long-term heat exposure, i.e., cable connectors, radio cabinets, T.V. set backs, under-the-hood automotive parts, lighting fixtures, etc. Product information and prices available, *Dept. SPE*, **Enjay Chemical Co., Room 1122, 15 W. 51 St., N. Y. 19, N. Y.**

Nylons for Increased Productivity

Two new Nylon 6 resins have been developed that are reported to increase production rates of injection molded parts significantly. The company reports that they have been field tested for six months and in many cases their use has reduced cycle times up to 40% in applications ranging from miniature parts produced in multiple-cavity molds to single-cavity molds taking up to three lbs. per shot. Write *Dept. SPE*, **Spencer Chemical Co., Dwight Building, Kansas City 5, Mo.**

Color Concentrate System for Polypropylene

Enjay Chemical Company announces a custom-matched concentrate system for polypropylene called Color-Pak. This coloring method which eliminates dusting during mixing is blended with the resin in the ratio of 1:10 before using. *Dept. SPE*, **Enjay Chemical Co., Room 1122, 15 West 51 St., N.Y. 19, N.Y.**

Styrene and Acrylate Emulsion Copolymers

Antara Chemicals of General Aniline and Film Corporation now have available in development quantities a new series of water emulsion copolymers of vinylpyrrolidone marketed under the trademark of Polectron. They offer dye receptivity, emulsion stability, excellent adhesive and unique film forming properties. Information from: *Dept. SPE*, **Antara Chemicals, Division, General Aniline and Film Corp., 435 Hudson St., N.Y. 14, N.Y.**

Ethylene-ethylene Acrylate Copolymer

Dow has developed this flexible polyolefin copolymer trademarked Zetafin. Dow indicates that the material can be molded on conventional injection molding equipment and offers processing advantages to flexible vinyls whose end uses are similar to those of Zetafin. *Dept. SPE*, **Paul A. Littlefield, Public Relations Dept., Dow Chemical Co., Midland, Mich.**

Fiberglas Roving

Owens Corning announces a new Fiberglas roving which is said to provide 25% faster wet-out, greater drapability and 10-15% improved laminate clarity. Inquiries: *Dept. SPE*, **Reinforced Plastics Division, Owens-Corning Fiberglas Corporation, 717 Fifth Ave., N.Y., N.Y.**

Nonionic Pigment Dispersions

Collway Pigments is introducing ten shades of nonionic water dispersions for simplified emulsion paint formulations, latex backed carpeting, vinyl backed fabrics etc. Collway claims high dependability and outstanding tinctorial value. Descriptive shade card. *Dept. SPE*, **Collway Pigments, a Division of General Aniline and Film Corporation, 435 Hudson Street, New York, 14, N. Y.**

Fluorescent Brightening Agent

Geigy's Tinopal SFG is used in plastic coatings, fibers, waxes and other organics. It absorbs ultraviolet radiations above 300mu, and increases the total amount of visible light reflected. Said to show good heat stability and is unaffected by most compounding and curing operations. Evaluated with both thermoplastic and thermosetting resins. *Dept. SPE*, **Advertising Dep't., Geigy Industrial Chemicals, Ardsley, New York.**

HARD COVER BINDERS

for SPE Journal

for SPE TRANSACTIONS

In recent months, the editorial office of SPE has received a number of requests from readers of the SPE Journal for hard cover binders. We are now about ready to make such binders available, not only for the SPE Journal, but for SPE TRANSACTIONS as well. Since the binders have to be purchased in quantity and in advance of sale, we would like to obtain an expression of interest from our readers as to how many would be interested in such hard cover binders.

Here are the details:

The binder is so designed to hold 12 issues of the SPE JOURNAL or SPE TRANSACTIONS. Individual issues can be easily inserted or removed ●

It would keep your copies of the SPE Journal neatly bound on a year-to-year basis ●

The year and volume number would be hot stamped down the spine for easy identification ●

Price—a nominal $3.00 ●

Please fill out the coupon below and send it to us. Remember, this is not an order for a hard binder. It is merely an expression of interest.

MAIL TO—SPE JOURNAL, 65 PROSPECT ST., STAMFORD, CONN.

Yes. I would be interested in purchasing a hard cover binder for my SPE JOURNALS and (or) my SPE TRANSACTIONS. If these were available I would order them as I have listed below.

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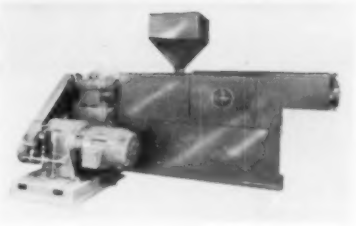
☐ Binder for SPE Journal

☐ Binder for SPE TRANSACTIONS

Vinyl Copolymers

Thompson Chemical Co. has added a new series of vinyl chloride and vinyl acetate copolymer resins to their line. Named Trulin 750 and 760, they have a vinyl acetate content of 13-15% and a volatile content of 2% max. Data Sheets: **Thompson Chemical Co., 90 Mendon Ave., Pawtucket, Rhode Island.**

EQUIPMENT



Plastic Extruder

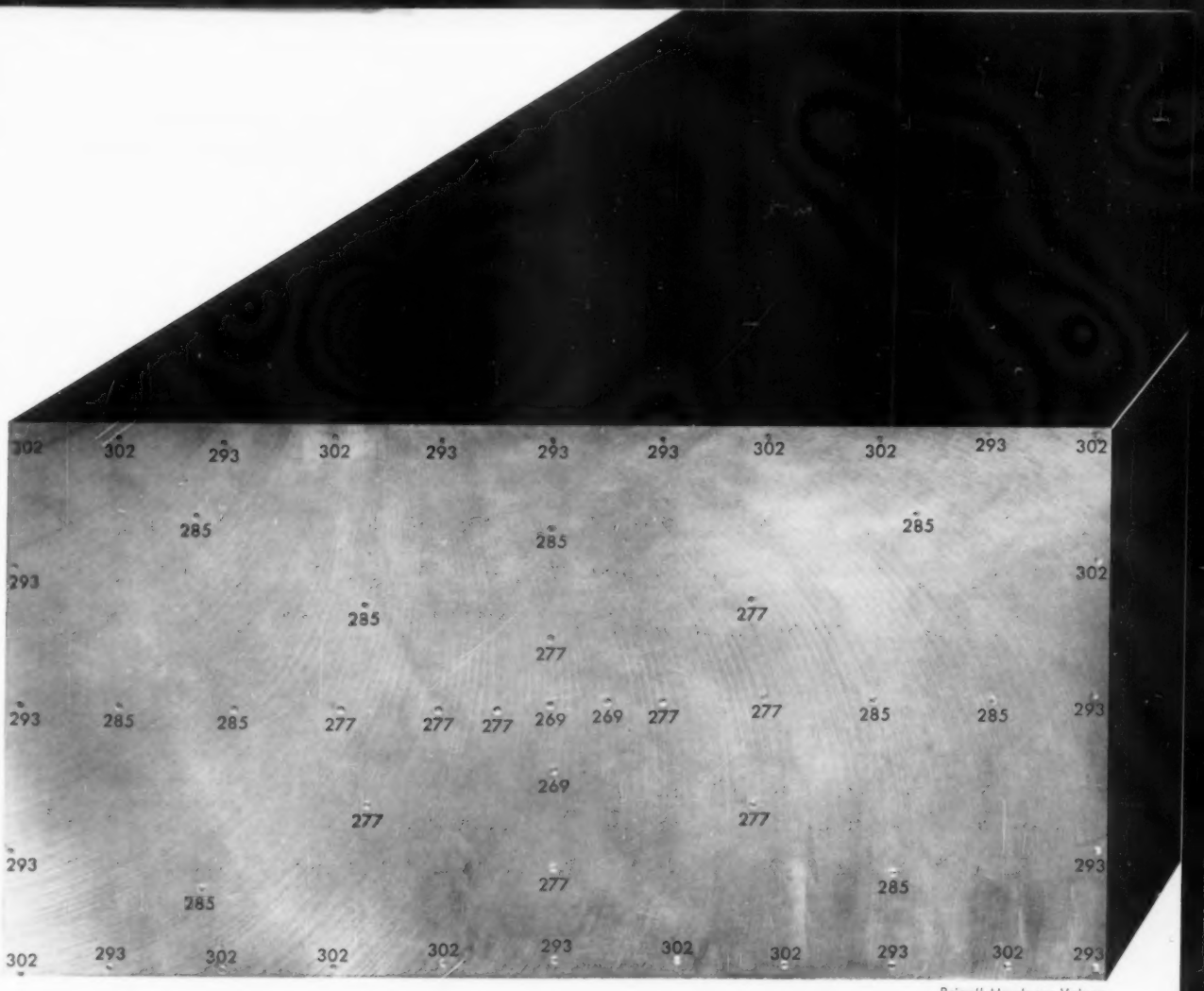
New thermoplastic extruder, equipped with continuous forced filtered oil system, water jacket, herring bone gear reducer and other mechanical ancillary items is said to operate at high efficiency with minimum maintenance. It has a 42-inch center line and is available in 1½ to 6-inch sizes. Information and specifications: *Dept. SPE*, **Olympia Tool and Machine Co., 119 Delancy St., Newark 5, N. J.**

Testing Dynamic Mechanical Properties

An instrument capable of testing small samples of materials, from hard glassy or metallic solids to soft gels, to determine behavior under physical stress is to be manufactured and distributed. It's unique in that it provides more precise measurements than have been previously obtainable with a single instrument, and over a broader range of conditions. Developed by Dr. Edwin R. Fitzgerald, with Prof. John D. Ferry at the University of Wisconsin, production is scheduled for mid-year. Information from *Dept. SPE*, **Chesapeake Instrument Corp., Shadyside, Md.**

High Frequency Spark Generators

A line of high frequency spark generators has been field-tested and proven to be a source of energy in treating the surface of polyethylene film, lay-flat tubing and coated paper. The treatment permits various types of printing, adhesion, etc. It is done in line with the extruder, with one or more electrodes used to treat either the entire width, single or multiple strips on one or both sides of the material. Write, *Dept. SPE*, **Lepel High Frequency Laboratories, Inc., Woodside, N.Y.**



Brinell Hardness Values

Better finishes for larger, longer-running molds and dies

This photo shows exactly why Crucible CSM 2 helps you build better molds and dies. Prehardened CSM 2 has more uniform hardness throughout the cross section. You can see this yourself in the 20"x10" specimen above, which was cut through the center of an 8-ft. forged bar. Just look at how constant the Brinell hardness values remain—across the surface...and from surface to center!

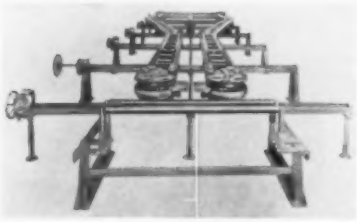
NEW **DENSIFYING** PROCESS IMPROVES CENTER SOUNDNESS—To uniform hardness has now been added greater center density. This is accomplished by **DENSIFYING,** a new process developed by Crucible which involves more than the normal consideration of steel analyses and amount of reduction. It includes careful appraisals of ingot size and shape, processing temperature control, and special methods of reduction.

This combination of higher hardenability and more uniform *density* ensures: more uniform polish from top to bottom of the cavity; greater resistance to washing at the cavity's center or bottom; more positive shut-off surface, particularly in internally landed molds and dies; more uniform machining characteristics from top to center of the cavity. It also eliminates the need to heat treat plastic injection molds and zinc die casting dies in sections up to 14" or 15" thick.

For further information on higher hardness, **DENSIFIED** CSM 2 and NU-DIE V® (H-13) mold and die steels, call your local Crucible steel service center. *Crucible Steel Company of America, Four Gateway Center, P.O. Box 88, Pittsburgh 30, Pennsylvania.*

CRUCIBLE STEEL COMPANY OF AMERICA

Film Tenters



Winsor and Jerauld have introduced their T-6P and LT-4P Film Tenters which were designed for laterally orienting a continuously produced plastic film sheet. If used with a longitudinal stretcher a biaxially oriented film results. Width adjusting and angle reducing devices are available. *Dept. SPE,* **Mr. John E. Waterman, Project Engineer, Winsor and Jerauld Manufacturing Co., 1268 Eddy Street, Providence 5, Rhode Island.**

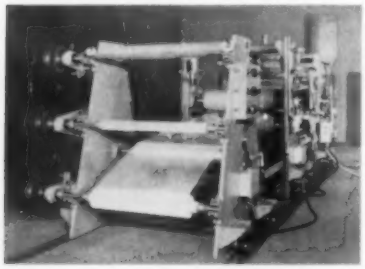
New 4-Inch Vacuum Diffusion Pump

Higher speed, by 120% over a one-third wider vacuum range than earlier models, is the claim for a new four-inch fractionating oil diffusion pump. It is also said to offer lower backstreaming, higher forepressure tolerance, greater capacity and reliable operation with minimal maintenance. Write *Dept. SPE,* **NRC Equipment Corp., 160 Charlemont St., Newton 61, Mass.**

New Vacuum Former

A new Automatic Vacuum Former will produce the high production requirements for formed plastics in packaging of food, hardware, instruments, and small parts products, as well as formed plastic parts for industrial use. Plastic material, 24 by 36 inches from rolls can be formed at the rate of three to six complete cycles per minute continuously. Write *Dept. SPE,* **Tronomatic Machine Mfg. Corp., 25 Bruckner Blvd., Bronx 54, N.Y.**

Heavy Duty Sheeting Line



A new integrated package is being presented which is said to provide versatility and precision production with a fine surface finish. Sheeting widths up to 72" at speeds up to 100 fpm and a wide range of gauges can be produced. Auxiliary equipment is available. Specifications and Literature: *Dept. SPE,* **Mr. B. C. Iannotta, Marketing Coordinator, Waldron Hartig Division, Midland Ross Corp., Box 791, New Brunswick, N.J.**

Gyrating Bin Activator

A new unit bin activator for feeding dry materials from storage to process has been developed. Self-contained, it includes a framework and gyrator assembly, and is suspended in a storage bin to promote the flow of solid materials around it. One will influence about 400 cu. ft. In large bins, two or more can be suspended within the storage area for free movement of the contents. *Dept. SPE,* **Vibra Screw Feeders, Inc., 156 Huron Ave., Clifton, N. J.**

For Speedy Handling of Plastic Preforms

Completely automated dielectric preheating of plastic preforms to molding temperatures is possible with the recently announced development of "Thermex" equipment. It is expected that costs will be reduced for manufacturers of molded plastic components of appliances, electrical apparatus and other industrial equipment, while production is accelerated and product uniformity increased. Write *Dept. SPE,* **Girdler Process Equip. Div., Chemetron Corp., Louisville, Ky.**

Sand-Coating Process Patented

A United States patent for a new sand-coating process has been awarded to F. W. Less, Dr. J. C. Searer and E. C. Roeck of the Durez Plastics Division, Hooker Chemical Corp., representing an important contribution to the production of metal castings. It is regarded as one of the first major improvements in the art of shell molding since its adoption by the American foundry industry. *Dept. SPE,* **Durez Plastics Div., Hooker Chemical Corp., No. Tonawanda, N.Y.**

Press for "Gunk" Process for Reinforced Plastics

A 350 ton H-P-M hydraulic press was designed with extremely fast closing, automatic slow downs and accurate controls of speeds and pressures. It has a 24" stroke and a maximum mold mounting space of 36" x 48" and is powered by a 60 HP motor. Inquire: *Dept. SPE,* **H-P-M Division, Koehring Co., Mount Gilead, Ohio.**

Small Thermoforming Machine

A small machine called Comet Jr., is available for sample work, cost estimating, product designing and evaluation of materials. *Dept. SPE.* **Comet Industries Inc., Franklin Park, Illinois.**

Wiring for Injection Machine Heating Cylinders

Injection Molders Supply Co., announces a new line of special glass insulated high heat resistant wire especially made for the injection molder. *Dept. SPE,* **Injection Molders Supply Co., Inc., 17601 South Miles Road, Cleveland 28, Ohio.**

New Ultrasonic Heatless Sealing Device

Sonoseal, a development of International Ultrasonics, Inc., welds hermetic seals, without disturbing the orientation of the molecular chain, thus maintaining strength of such materials as Mylar and Cronar. A mobile console form is demonstrated. *Dept. SPE,* **International Ultrasonics, Inc., 331 Centennial Avenue, Cranford, New Jersey.**

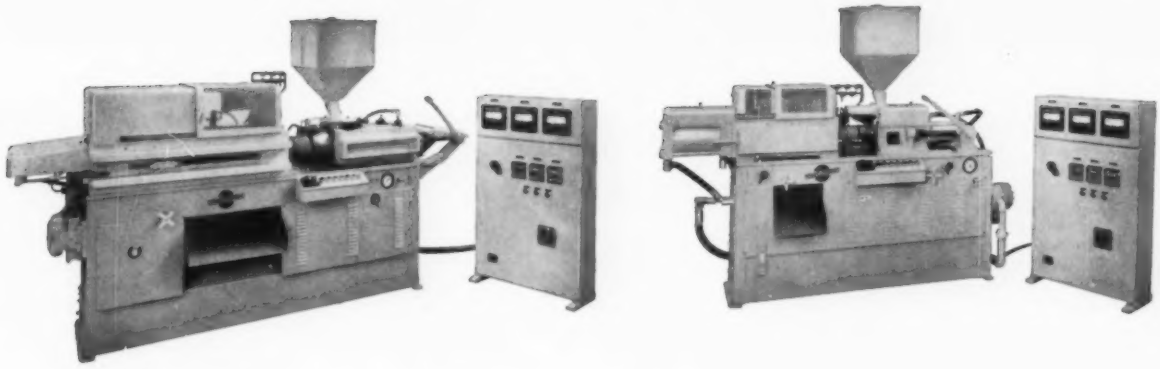
MANUFACTURERS' LITERATURE

Decorating Polyethylene

Variations in decorating techniques for both treated and untreated low and high density polyethylenes are covered in a 16-page illustrated brochure. Various methods used are noted with a complete appendix listing some 250 sources for the services, equipment, and supplies. Write *Dept. SPE,* **W. R. Grace & Co., Dept. 119, Polymer Chemicals Div., 225 Allwood Rd., Clifton, N.J.**

Pressure Forming Machine Described

A new Laboratory Pressure Forming Machine, Model P-88, reputedly engineered for years of trouble free service is the subject of a one-page bulletin now available. The machine's push-button control, reliable heat and pressure systems, are said to render it ideal for product sampling and development work. Write *Dept. SPE,* **Plastics Machinery Div., The Producto Machine Co., 990 Housatonic Ave., Bridgeport 1, Conn.**



STC

AUTOMOLDER

KE-100-5D / KE-5C-5D

In another triumph of engineering skill Standard Tool offers two of the most ingenious two ounce injection molding machines ever designed. Available in four types these new machines may be specified with electrical or cam operated controls, and with a choice of 6¼" or 9" stroke. Write for more details of these newest of Standard's Golden Anniversary AUTOMOLDERS.

MORE TONS CLAMP PER SQUARE FOOT OF FLOOR SPACE

STANDARD TOOL COMPANY

ENGINEERING PLASTICS SINCE 1911 . . . ENGINEERING, CASTING, MOLD MAKING AND MACHINERY

BUILT BY STANDARD TOOL COMPANY, LEOMINSTER, MASSACHUSETTS • SOLD BY KAVANAGH SALES INC., LEOMINSTER, MASSACHUSETTS AND FOREIGN REPRESENTATIVES

Employment & Service Guide

POSITIONS OPEN

PLASTICS DEVELOPMENT ENGINEER

We have an attractive opening in our New Product Development Dept. for an engineer or chemist to work on fabrication techniques for new thermoplastics. B.S. minimum, 3-10 years broad experience in fabrication of plastics, especially extrusion. Send resume in confidence to Dr. David M. Clark, Director of Technical Recruiting, W. R. Grace & Co., Research Division, Clarksville, Md.

"CHEMICAL ENGINEERS AND CHEMISTS" PRODUCT DEVELOPMENT—PLASTICS

Excellent growth opportunity in expanding company for Chemists or Chemical Engineers with experience in formulation of thermosetting compounds in Coatings, Adhesives, Encapsulating or Tooling fields. Must be capable of assuming responsibility for Product Design, Application Development and Technical Service. Creative and leadership abilities essential. West Los Angeles. Write Box No. 228, SPE JOURNAL.

POLYETHYLENE SALES REPRESENTATIVES

(Chemistry or Chemical Engineering Degree)

Goodrich-Gulf Chemicals, Inc., a growth Company in the fields of synthetic rubbers, plastics and petro-chemicals, has openings for polyethylene sales representatives with three to five years selling experience in plastics field. Research or development experience desirable.

Please submit your complete resume in confidence to:

Employee Relations Department
GOODRICH-GULF CHEMICALS, INC.
1717 East Ninth Street
Cleveland 14, Ohio

EXTRUSION LABORATORY SUPERVISOR

Must have solid background in extrusion processes, theory, and equipment. Will be responsible direct to the Director of Research:

Overall Laboratory operation

Evaluation and reporting of test data

Customer contact in conjunction with laboratory tests

Some travel for specific field problems.

All replies held in strict confidence.

Contact Box No. 238, SPE JOURNAL

PVC COMPOUNDING SECTION HEAD

Excellent opening Technical Service Laboratory for chemist experienced in compounding vinyl resins. Work involves the development of new compounds, evaluation of new resins and technical service. Permanent position, excellent working conditions.

Send resume and salary requirements to:

Dr. M. W. Kline
The Borden Chemical Co.
Polyvinyl Chloride Dept.
60 Elm Hill Ave.
Leominster, Mass.

WANTED— FOR PRODUCT AND MARKET DEVELOPMENT

Plastics Engineer familiar with molding and extrusion operations of polystyrenes and related products. Activities will include evaluation of new products in applications and testing laboratories, introduction of products to potential users, and contacts with sales, technical service and research personnel. Modern, well-equipped laboratory with congenial and pleasant working conditions located in Western Pennsylvania. Send resume and salary requirements in confidence to:

Manager, Product Development
Koppers Company, Inc.
Plastics Division
Post Office Box 65
Monaca, Pennsylvania

POSITIONS WANTED

MANUFACTURING EXECUTIVE

Former Vice-President Manufacturing. Production, Quality, Tool and Product Design. Cost Reduction. Sales Engineering. Desires Position Manufacturing, Design & Sales Engineering. Experience: Injection, Extrusion, Tube Blowing, Casting and Polyester Laminates. Age 42. Experience 22 years. Presently Employed. Will Relocate. Reply Box No. 229, SPE JOURNAL.

PRODUCT DEVELOPMENT ENGINEER

Extensive experience in design of metal and injection molded plastic components and sub-assemblies. Three years liaison work with automotive and major appliance industry. Desire position with growth potential in or near Chicago in product development and/or sales. B.S. Degree—married. Box No. 234, SPE JOURNAL.

CLASSIFIED INFORMATION AND RATES

SPE members in good standing are entitled to a total of three no-charge "Positions Wanted" advertisements within any 12-month period, each ad (not to exceed 50 words) should include training, experience, location desired; headline (not to exceed 3 words) must state job description. Additional words will be charged @ 25¢. *Do not* submit resumes: none are kept on file.

Last day for inserting all classified ads is the first day of the month preceding date of publication, except for display size ads which close on the 15th of month preceding issue date.

"Positions Open" and "Positions Wanted" —$12.50 per column inch, 2¼ inches wide. (35 characters per line; 7 lines per inch).

Minimum charge: $12.50. Pre-publication contact, known as the "Availability File"—$5 service charge on "Positions Open"; no charge to SPE members. *See adjacent box for a description of how it works.* "Products and Services" and "Business Opportunities" —$20.00 per inch. Minimum charge: $20.00.

All ads include one bold face caption line. Additional caption lines @ $2.50 extra per line. Boxed ads (4-sided rule)—$3.00 extra. Agency commission allowed *only* on ads 5 inches or more in depth. Display ads of 1/16 page or more are charged at regular advertising space rates. No ¼ page or vertical ⅛ page ads published within Employment Service Guide section. Typesetting (non-commissionable) will be charged at cost.

HOW OUR "AVAILABILITY FILE" WORKS

If you are a company, or an SPE member who will be advertising in SPE JOURNAL, you can receive copies of those classified ads of potential interest to you *before* they are actually published in the Journal, provided that these advertisers have also indicated their interest in the same procedure. This pre-publication contact is what we call our "Availability File". All you have to do to participate is to sign the return postcard we send you upon receipt of your advertising insertion. When your card is returned, the ads are sent to you as they come in, up to publication date.

SALESMAN

College background. Experienced in laminated plastics, printing, extrusion and calendering of vinyl poly film and sheeting. Desires challenging sales position. Box No. 231, SPE JOURNAL.

PLASTICS ENGINEER

Mechanical engineer, 20 years experience in all fields of plastic molding, production, supervision, machine & tool designing, project and methods engineering. Can follow through from job inception to on-time completion, coordinating all phases of procurement, engineering and production. Eastern area preferred. Resume on request. Box No. 233, SPE JOURNAL.

PLANT ENGINEER

25 years experience in all phases process material handling and plant layout. Broad, versatile background includes manufacturing, design and methods assignments, plus executive and supervisory functions in all types metal-working, plastics and rubber molding and opthalmic and precision lens manufacturing. Will relocate. Excellent references. Resume. Box No. 237, SPE JOURNAL.

MANUFACTURERS' AGENT

seeks to represent reliable company specializing in *vinyl extrusions*.

Territory: Michigan. Box No. 232, SPE JOURNAL.

BLOW MOLDER

7 years experience in the extrusion and vacuum forming field; 5 years experience in blow molding, machine and mold design, plant maintenance, production, R. & D., management of three shift operation. Desires responsible position with established firm. Willing to relocate. B.S. Degree, etc. Box No. 230, SPE JOURNAL.

CHALLENGING POSITION

desired in plastics or related field. 19 years diversified experience. Lab. Dir., industrial research, development, process and product improvement, quality control, evaluation; thermoplastics, granuplasts, thermosets, finishes, special effects, colors, fastenings; injection, compression molding B.S. Chemistry. Age 39. Will relocate. Travel some. Resume. Box No. 225, SPE JOURNAL.

CHIEF ENGINEER

Thirty-four years old, five years experience with large compression, injection, and reinforced sheet molder. Previous position as Tool Engineer, Equipment, and Product Designer, provides background for managerial level challenging position. B.S. Physics and Mathematics. Architectural training, and automotive experience. Will relocate. Box No. 236, SPE JOURNAL.

PLASTIC DESIGN ENGINEER

Mechanical Engineer, 34, with over 14 years experience in all phases of thermoplastic molding and finishing desires challenging position in Midwest. Will relocate. Especially adept at part and mold design for both injection and blow molding. Box No. 235, SPE JOURNAL.

EUROPEAN ASSIGNMENT: PLASTICS

Chem. Eng. 11 years broad experience polymers, product development thermoset/thermoplastics. Has accomplishments in coatings, molding, extrusion, lamination, varnishes and other plastics processes. Patents. Graduated in France. US citizen. Desires challenging opportunities with International division of Am. Corp. Prefers France or Switzerland. Box No. 242, SPE JOURNAL.

PRODUCTS & SERVICES

MOLDS

Injection compression transfer, quality molds, good delivery, competitive prices. Tested before delivery, laid down in your plant. Steel Dies & Moulds Ltd., 43 Raleigh Ave., Toronto, Canada. PH. AM 1-7092

INJECTION • BLOWING
COMPRESSION • TRANSFERS

MOLDS

Quick Delivery, Cheapest Prices

DANISH MOULD ENGINEERING

Osterbrogade 54D

phone **TRIA 3100** • *cable* **DANIMOLD**
COPENHAGEN, DENMARK

BUSINESS OPPORTUNITIES

FOR SALE

Going business, one of the largest manufacturers of plastic containers, with or without modern building, includes: 8 Impco Inj. Machines, '58-'61 models, 4 Cosom and Markem Printing Machines (late), 10 Automatic Container Molds, Asst'd Sizes, 10 Automatic Cover Molds to Match Containers.

Also, complete list of customers, sales, orders, etc. This is a large volume business. Owner wishes to retire. For complete details write Box No. 227, SPE JOURNAL.

NEW LITERATURE

Reference Charts Published

Three Handy Reference Charts for injection molding superintendents and press operators are available. Center punched on 8½"x11" card stock for posting, one gives the number of pieces in pounds, based on weight of one piece in grams; another, the conversion of grams into ounces at a glance, and the third is an electric amperage conversion table. Write *Dept. SPE*, **Injection Molders Supply Co., Inc., 17601 South Miles Rd., Cleveland 28, Ohio.**

New Formulation for Blister And Skin Packaging Described

Materials Bulletin No. 7 details typical extrusion conditions and properties of a new formulation developed especially for extrusion into clear sheet that will not "blush" cloud or haze when subjected to deep-draw vacuum forming. Check *Dept. SPE*, **Plastics Div., Eastman Chemicals Products, Inc., Kingsport, Tenn.**

Motodrive Catalog

A new 88-page publication covering the complete line of Vari-Speed Motodrives, ¼ through 40 hp has been printed. Tables, diagrams, charts for over 100 different assemblies are included. The company's entire line can be reviewed in the new G-100 Catalog. Check *Dept. SPE*, **Reliance Electric and Engineering Co., 24701 Euclid Ave., Cleveland 17, Ohio.**

Buyers Guide to Mold Releases

A 16-page Buyers Guide to Silicone and other Mold Releases is available in a handy pocket size. Prices and information and uses for all types of Parting Agents are tabulated. A "must" for the purchasing agent. Send for it from *Dept. SPE*, **Injection Molders Supply Co., Inc., 17601 S. Miles Rd., Cleveland 28, Ohio.**

Commercial and Laboratory Extruders

A profusely illustrated, two-color, 12-page Bulletin, HK-10 describes commercial and laboratory extruders used in plastic coating of paper board and other web materials. Specifications are included with the review of the entire line of equipment. Write *Dept. SPE*, **Hale & Kullgren Plastics Dept. of the Black-Clawson Co., 613 E. Tallmadge Ave., Akron, Ohio.**

Vacuum Metallizing

A systems guide in chart form is the major portion of a 4-page brochure describing metallizing coatings systems which

may be applied by spraying, dipping or flow coating to thermoplastics, thermosetting plastics, metals and glass. Thinning information and system properties are included. *Dept. SPE*, **Bee Chemical Co., 2700 E. 170 St., Lansing, Ill.**

Injection Molders' Reference Charts

Injection Molders Supply Co., announces two new additions in their series of charts. The molder can easily calculate heating cylinder plasticizing capacity requirements with these demand factor charts. *Dept. SPE*, **Injection Molders Supply Co. Inc., 17601 South Miles Road, Cleveland 28, Ohio.**

Electrical Insulating Materials Chart

An electrical properties chart of epoxy insulating materials features both amine and anhydride curing agents. Physical properties are also included. *Dept. SPE*, **Furane Plastics Incorporated, 4516 Brazil Street, Los Angeles 39, California.**

■

(Continued from page 557)

hour. Thus, as an approximation

$$M = \frac{K}{(H-C)^n} = \frac{225\ V}{R}, \text{ or}$$

$$(H-C)^n = K\frac{R}{V} \qquad (3)$$

The safe operating temperature is thus seen to be related to the ratio of inventory to output capacity. Obviously if the shot size varied(as it would for different sizes of parts) but the cycle remained the same, the ratio of R/V would vary and the safe operating temperature would vary. Thus, if a larger cylinder were used to obtain better plasticating at a lower temperature it is quite apparent that the decrease in ratio of R/V would decrease the safe operating temperature H at an exponential rate so that the effect would be opposite to that desired.

This result of the mathematical study has been borne out by actual production runs on both PVC and a polyacetal. A similar result was obtained with nylon and the end result of the nylon test showed a very marked control over dimensional shrinkage that was not anticipated. Applying this same technique to other heat-sensitive compounds is expected to yield similar results with the end effect being an increase in quality and a definite improvement in the properties of the final product.

■

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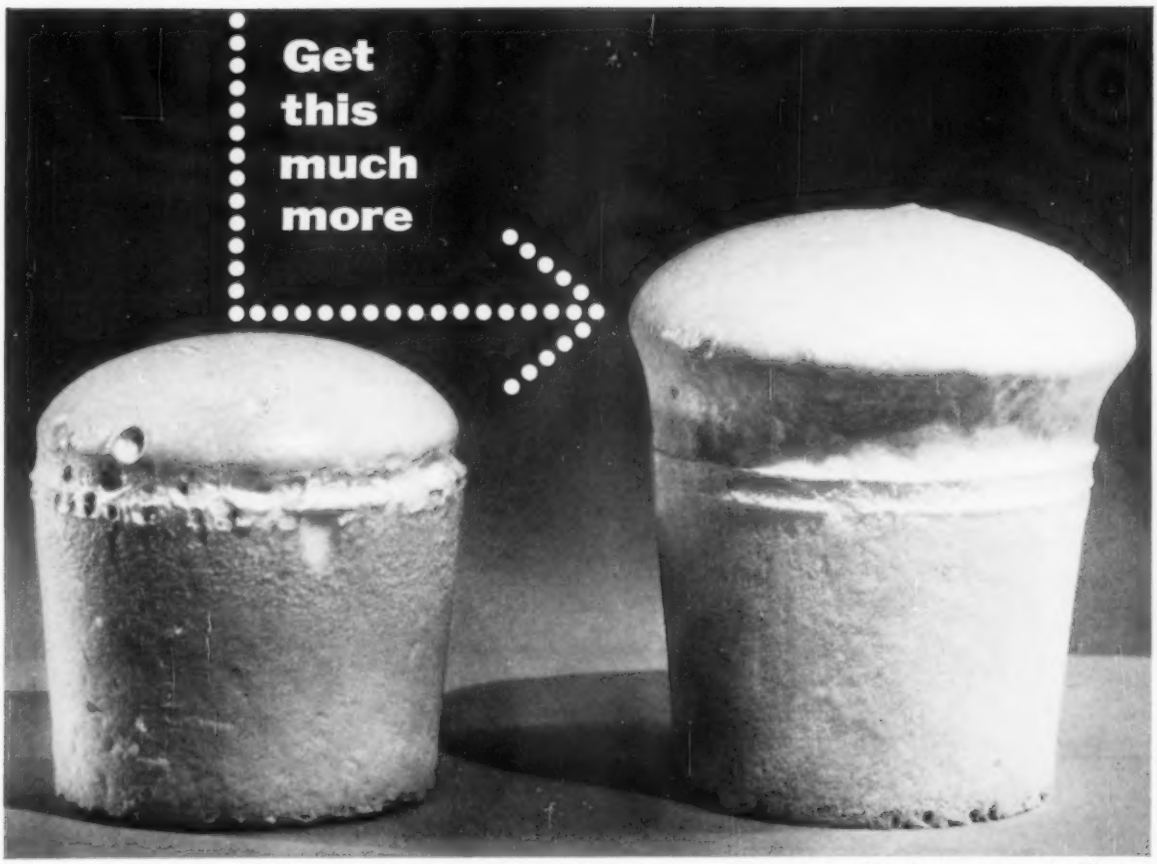

Above: "Genetron" blowing agent makes the difference . . . yields extra cubic volume . . . softer foam!

Get this much more urethane flexible foam with genetron® auxiliary blowing agents!

Now, produce larger volumes of improved urethane flexible foams at lower cost! Use "Genetron" halogenated hydrocarbon gas as an auxiliary blowing agent for these important advantages:

Decreased density! Decreased costs! The density of flexible polyether foams blown with "Genetron" decreases according to the quantity of "Genetron" used. This is usually between 10% and 15% of total ingredients. Using "Genetron" you get larger volumes of foam . . . with significant cost savings!

Lower Compression Loads! With "Genetron", less force is required to produce a specified deflection. Result: a softer foam far more suitable for use in furniture manufacture, automotive seating, bedding, and other uses where comfort cushioning is desired. And "Genetron" 11 will not produce any marked change in other physical properties.

General Chemical's technical service is available to assist customers with "Genetron" applications in the field. Write today for further information.

Other major components of the urethane foam system are also produced by Divisions of Allied Chemical. Namely, Nacconate® diisocyanates by National Aniline Division; resins by Plastics and Coal Chemicals Division.

Basic to America's Progress

Allied Chemical

GENERAL CHEMICAL DIVISION

40 Rector Street, New York 6, N. Y.

INJECTION MOLDED—This hospital footstool is typical of the products and parts made of MARLEX for hardware, auto, appliance, furniture, housewares, toy, and other industries. (Footstool, Consolidated Molded Products, Scranton, Pa.)

THERMOFORMED—Many items are economically formed of MARLEX sheet: tote boxes, trays, automotive and industrial components, food packages . . . even light, sturdy boats. (" SPORTYAK ®, Woodall Industries, Inc., Detroit 34, Mich.)

BLOW MOLDED—MARLEX blow molding resins provide superior lampshades, containers . . . a variety of large and small components. (Container, HYSPEC by Hydrocarbon, Keyport, N. J.) (Lampshade, Haveg Industries, Bound Brook, N. J.)

By every method . . .
MARLEX* quality assures success

MARLEX high density polyethylenes, ethylene copolymers and tailored resins afford you versatility and outstanding product quality at moderate cost. They enable you to produce items which are durable, tough, light, corrosion proof and rot proof . . . and produce them at low cost. Products made of MARLEX withstand temperature extremes (−180°F to 250°F)... acids, alkalies, oils and greases. Get complete information about MARLEX today! Your inquiry will get prompt attention and an early response.

*MARLEX is a trademark for Phillips family of olefin polymers.

EXTRUDED—Large and small pipe for many uses, electrical conduit, filament and yarn for rope and fabric, sheet or clear film . . . are extruded products made better of MARLEX.

BLOWN FILM—Thin, yet tough, strong and light, MARLEX is used for bulk bags, construction barriers, agricultural and industrial films. (Bag, Crystal-X Corp., Lenni Mills, Pa.)

PHILLIPS CHEMICAL COMPANY, Bartlesville, Oklahoma, a subsidiary of Phillips Petroleum Company

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GEneva 4-7600	Digby 4-3484	FRanklin 6-4126	TErrace 4-6600	MUrray 1-6997	EMerson 8-1358

EXPORT: PHILLIPS PETROLEUM INTERNATIONAL CORPORATION • P. O. Box 7239, Panama City, Panama • Sumatrastrasse 27, Zurich 6, Switzerland

PHILLIPS 66 MARLEX PLASTICS